SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

DECEMBER 1900.

GENERAL PHYSICS.

2377. *Elasticity of Metals and Temperature.* **C. Schaefer.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 122–126, 1900.)—The elasticity of metals is here investigated at very low temperatures, down to — 186° C., the boiling-point of liquid air. Both the longitudinal and torsional moduli are measured and the temperature coefficient of each is determined. The metals used were in the form of wires, and the same apparatus was used to determine both moduli. The lower scale-pan was supported by two rods from a cross-bar which was fastened to an aluminium tube surrounding the wire, the bottom of the tube being fastened to the lower end of the wire. The scale-pan, cross-bar, and tube were thus hanging on the wire and acted as a vibrator in the torsional experiments. The tube served to hold the cooling agents. One determination of the modulus of torsion was made for each wire by the vibrational method, and then the torsional static deflections under a constant couple at the various temperatures gave the temperature coefficient of torsion.

The results are :—1. The longitudinal and torsional moduli (η and k) between the temperatures $+20°$ and $-186°$ C. are represented by the equations—

$$\eta_t = \eta_{20}\left\{1 - \alpha(t - 20)\right\}$$
$$k_t = k_{20}\left\{1 - \beta(t - 20)\right\}$$

2. The temperature coefficient of the torsional modulus (β) is greater than that of the longitudinal modulus, and in consequence the lateral contraction μ increases with the temperature. 3. The greater the thermal coefficient of expansion, or the lower the melting-point, the higher is the temperature coefficient (gold forming an exception). 4. The elastic lag or hysteresis was measured in Al, Ag, and Cu. In all three it was approximately the same at ordinary temperatures, and at — 186° it was quite inappreciable. 5. The limits of elasticity were raised by lowering the temperature. 6. The lateral contraction may be expressed in the form—

$$1 + \mu_t = (1 + \mu_{20})\frac{1 - \alpha(t - 20)}{1 - \beta(t - 20}.$$

The temperature calculated from this equation, which would give a value of μ_t equal to $\frac{1}{2}$, is approximately the melting-point of the metal. This agrees with theory.

The author gives a comparison of his experimental results for temperature 20° with those of other experimenters. The following table gives his numerical results for the metals used.

Metal.	Mean Coeff. of Expansion between 0 and 100°.	k_{20} in kg. per mm².	Δk in % per 100° C.	η_{20} in kg. per mm².	$\Delta\eta$ in % per 100° C.	μ_{20}.	Melting-point.	
							Observed.	Calculated.
Platinum	$0{\cdot}0_5907$	6,593	1·78	16,029	0·732	0·215	1,765	1,741
Palladium	$0{\cdot}0_41104$	4,613	2·696	11,284	1·979	0·223	1,578	1,724
Iron	$0{\cdot}0_41113$	7,337	3·035	18,347	2·250	0·247	1,500	1,470
Nickel	$0{\cdot}0_41279$	9,518	3·280	23,544	2·463	0·239	1,400	1,391
Gold	$0{\cdot}0_41454$	—	3·014	—	—	—	1,070	—
Copper	$0{\cdot}0_41698$	3,967	4·489	9,897	3·627	0·245	1,100	1,169
Silver	$0{\cdot}0_41900$	2,467	8·209	5,897	7·65	0·195	970	990
Aluminium ...	$0{\cdot}0_42336$	2,329	24·72	6,330	21·32	0·359	645	—
Zinc	$0{\cdot}0_42905$	1,614	48·37	4,296	—	0·331	419	—
Lead	$0{\cdot}0_42948$	550	78·67	1,493	—	0·431	327	—

J. B. H.

2378. *Natural Units.* **M. Thiesen.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 116–121, 1900.)—Planck has shown that Wien's law furnishes us with two constants which, together with the constant of gravitation and the velocity of light, may be taken as the foundation of a new system of units which are independent of the properties of any particular body. [Abstract No. 497 (1900).] Thiesen considers that the formula given by Wien for the partition of energy in the spectrum of a radiating black body is not sufficiently substantiated for the constants which occur in it to be taken as the foundation of a new system of units, but he takes other constants, obtained from the laws of radiation connecting the total radiation and the wave-length of the maximum radiation with the temperature and applies these in place of the others. The five fundamental units are then the velocity of light, the constant of gravitation, the constant of electric attraction in Coulomb's law, and the above two constants of radiation. He then expresses other well-known physical constants in terms of these units by aid of their dimensions, and on substituting the numerical values obtains numerical relationships between the various constants, some of which agree closely with experimentally determined values. The constants thus treated are: The gas temperature-pressure constant; the elementary electric charge on an ion in electrolysis; Lorenz's degree of temperature, *i.e.*, the rise in temperature caused by unit of work applied to the number of atoms separated from an electrolyte by unit of electricity; Lorenz's constant or the heat conductivities of metals divided by the electrical conductivity and by the absolute temperature; and the relation between the charge and the mass of the particles in kathode rays. J. B. H.

2379. *Working Silica in the Oxy-gas Blowpipe Flame.* **W. A. Shenstone** and **H. G. Lacell.** (Nature, 62. pp. 20–22, May 3, 1900.)—The authors here give the results of their experience in making rods, tubes, and bulbs of various diameters of fused quartz.

Native masses of rock crystal are used. These are heated in a Bunsen flame until the outer impure layers can be removed easily by a blow from an iron pestle or hammer. The clean masses of silica are then heated for some time in a vessel containing boiling water and dropped whilst hot into clean cold water. This treatment will cause the masses to crack to such an extent that they may easily be broken into fragments of convenient dimensions by sharp blows from a clean hammer. When the material has thus been broken up, the fragments are examined and all those containing foreign matter are rejected. The remainder are then heated to a yellow-red heat in a platinum dish and then quickly thrown into deep cylinders containing cold distilled water. The quartz has then the appearance of white enamel, and may be safely brought into the oxy-gas flame or be pressed against masses of white-hot plastic silica without preliminary heating.

Silica rods are made by joining piece to piece in the oxy-gas flame, care being taken to avoid enclosing air-bubbles by always fusing from below upwards. Tubes are made by binding a few rods round a small rod of platinum and fusing them together so as to form a rough tube; then after closing one end of this tube a small bulb is blown at its end. The bottom of the bulb is heated and a rod of silica attached. The whole bulb is then heated and drawn out into a tube.

Vitreous silica is less hard than chalcedony, but harder than felspar. Its surface hardness does not appear to be altered by any process of heating and cooling. Tubes may be cut by a diamond or by a file of hardened steel. The authors attribute the rotting of threads of silica to surface devitrification. This can be prevented, according to Gaudin, by heating to a suitable temperature. J. B. H.

2380. *Spiral-spring Balance.* **C. E. Linebarger.** (Phys. Rev. 11. pp. 110–111, Aug., 1900.)—A new form of Jolly balance is described in which the lower portion of the spring is brought to a fixed zero by moving its upper point of support up or down. A vertical tube fixed to a tripod contains a second tube sliding within it to which at its upper extremity is attached a cross-piece supporting the spiral-spring. This second tube has a millimeter scale attached, and is moved up and down by a milled head gearing with a rack. To the lower end of the spring is attached a piece of aluminium foil with zero mark, which moves in a short glass tube also with zero mark. The glass tube, which is attached to a clamp on the fixed tube, prevents excessive lateral or longitudinal motion of the spring. G. H. B.

2381. *Stop-clock for Atwood's Machine.* **W. C. Baker.** (Phys. Rev. 11. pp. 105–109, Aug., 1900.)—The clock is driven by a weight and regulated by a fan. A shaft rotating once in about 1½ seconds carries a wheel of 100 teeth, running loose on a sleeve on the shaft, to which is attached a pointer moving over a scale. Attached to the shaft is a light spring which presses on the face of the wheel with just enough friction to turn it with the shaft, but which slips as soon as a catch engages with one of the wheel teeth and holds it stationary. Two electromagnetic catches engage with the wheel; one releases the wheel (which is then turned by the clock-shaft) when the weight of the Atwood machine is released, and the other stops the wheel when the weight reaches the lower contact. G. H. B.

2382. *Modulus of Elasticity and Magnetisation.* **J. S. Stevens.** (Phys. Rev. 11. pp. 95–100, Aug., 1900.)—In previous papers the relation between magnetisation and the moduli of flexional and torsional elasticity has been discussed [see Abstracts Nos. 202 and 1311 (1900)]. This paper deals with elasticity of traction and that of compression. A coil of wire was wound on a brass tube through which passed a stream of running water, in which was held the wire to be tested. One end of the wire was fastened to a rigid iron support and the other attached to a bent lever with a multiplying power of about 11. At the other end of the lever were attached weights which gave a tension on the wire of $5{\cdot}39 \times 10^6$, $10{\cdot}78 \times 10^6$, and $19{\cdot}6 \times 10^6$ dynes respectively. The changes in length were communicated to another arm of the same lever, which multiplied the effect 110 times. The free end of this lever moved under the field of a micrometer microscope. Two wires were tested, each 175 cm. in length, and having diameters of 0·73 and 0·98 mm. respectively. The number of turns in the magnetising coil was 1,612, and the magnetising current was varied from 2·12 to 8 amperes in the different experiments. The conclusions obtained were as follows:—(1) The modulus of elasticity of traction increases when the body is magnetised. (2) The increase is fairly proportional to the magnetising force. (3) With the same wire the change in the modulus varies with the stretching weight. (4) With wires of different cross sections, stretched by the same load, the change in modulus is greater with the smaller wire.

In the experiments on the elasticity of compression a bar 134·5 cm. in length and 2·54 cm. in diameter was employed. The compression employed varied from 270 kilos. to 1,350 kilos. The magnetising current was varied from 0·5 to 23 amperes, the number of turns in the magnetising coil being 1,830. It was found that within the limits of this experiment magnetisation does not change the elastic modulus for compression. If it had been possible to apply a pressure nearer to that of the elastic limit of the metal the results might have been different. E. C. R.

2383. *Thermal and Electrical Conductivity of Soft Iron.* **E. H. Hall.** (Amer. Acad., Proc. 36. pp. 121–141, Aug., 1900.)—Full details are here given of the investigation, the result of which as to heat-conductivity is given in Abstract No. 2002 (1900). The iron experimented with was of density 7·785 at 0° C., and its percentage composition was Fe 99·93, C 0·059. The thermal conductivity was $0{\cdot}1541\,(1 - 0{\cdot}0003t)$, its specific conductivity was 0·0000817 at 18° C., and its thermo-electric quality as compared with copper ranged from 0·00001028 at 26·6° C. to 0·00000870 at 71·1° C. In the heat experiment the iron was used in the form of a disc with its faces heavily plated with copper and heated by flowing water. Platinum spirals were used to determine the temperatures, and an important discussion is the temperature-effect due to their copper leads. R. E. B.

2384. *Impact.* **J. H. Vincent.** (Cambridge Phil. Soc., Proc. 10. pp. 332–357, Aug. 13, 1900.)—If e_0 be the coefficient of restitution for an infinitely small velocity of approach and e the same for a given velocity u of approach, $e = e_0 - mu$; and the velocity of rebound is $e_0u - mu^2$, which has a limiting maximum value. The above applies to rubber balls at any velocity of approach; for a steel ball impinging on the plane surface of a lead, paraffin, brass or cast-iron block, e rises rapidly when the velocity of approach becomes small, but for large velocities of approach the above formula holds good. Hammering the surface of lead increases e. When non-deformable spheres impinge on plane surfaces of lead, paraffin, brass, or cast-iron with velocities of impact which are not too great, the square of the diameter of the dent is proportional to the velocity of impact; and for spheres of the same material impinging with the same velocity, the diameter of the dent is proportional to the diameter of the sphere. When e is small (lead and paraffin) the time taken by any one sphere to produce a dent is independent of the velocity of impact, and the pressure (p) between the surfaces in contact is constant during this time (lead from 6×10^8 to 13×10^8 dynes/cm.^{2}; soft paraffin about 1×10^6 dynes/cm.^{2}). The volume of the dent is proportional to the energy of motion of the sphere just before impact. For steady loads the square of the diameter of the dent is proportional to the load; the pressure p between the surfaces in contact is constant and about one-half of p. The time of impact is directly proportional to the diameter of the impinging ball if other things be constant. A. D.

2385. *Surface-tensions of Homologous Series and Supercooled Liquids.* **J. Hock.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 1516–1528, 1899.)—Measurements by means of Jäger's apparatus (Sitzb. B. 100. IIa. p. 493) of the capillary-constants of the following liquids: Methyl, ethyl, propyl, butyl, and amyl alcohols, and formic, acetic, propionic, butyric, valeric, and caproic acids. The measurements for each liquid were made through a wide temperature range and *Brunner's law* (surface-tension a linear function of temperature) verified. No simple connection could be found between surface tension and chemical composition in the two homologous series investigated, and no break occurred in the curve for a supercooled liquid in passing through the melting-point. F. G. D.

2386. *Brown's Molecular Motions.* **F. M. Exner.** (Ann. d. Physik, 2. 4. pp. 843–847, Aug., 1900.)—Gum was dissolved in alcohol and precipitated by water, and the small particles so obtained were used for studying Brown's molecular motions. The motions were traced on smoked glass by means of Abbe's tracing device, and the distances traversed, divided by the time, gave the velocity of the particles. Such measurements were made for various temperatures and for particles of various diameters. Thus at a temperature of 23° a velocity of 0·0038 mm. per sec. was found in particles of 0·0004 mm. in diameter, 0·0033 mm. in particles 0·0009 mm. in diameter, and 0·0027 mm. in particles 0·0013 mm. in diameter. There is also a slight increase of the velocity with the temperature, but the temperature curve obtained indicates that all motion would cease at — 20° C. rather than at the absolute zero. The author supposes the motions to have some connection with the motions of the liquid molecules themselves, though the velocity of the latter is some 100,000 times greater. E. E. F.

2387. *Discontinuity in the Propagation of Explosive Phenomena.* **P. Vieille.** (Comptes Rendus, 131. pp. 413–416, Aug. 13, 1900.)—The author brings forward two hypotheses by means of which the high velocities of propagation of explosive phenomena can be explained. The first of these regards the explosion as composed of two parts, the reaction being produced by a preliminary rise in temperature due to the purely physical phenomenon of adiabatic compression of the medium which is considered as inert; the chemical part of the action merely modifies the composition of the medium in which the mechanical wave is propagated and maintains the high value of the condensation produced by the wave. The speed of propagation is hence that of a disturbance in the inert medium, and this cannot differ from the normal speed of sound in the medium until discontinuity sets in in the wave-front; as soon as this occurs a new elasticity comes into play, and this has a higher value as the discontinuity of pressures on the wave-front becomes greater. The second hypothesis regards the medium as in a state of chemical equilibrium, and in this case the characteristic equation depends not only on two independent variables—temperature and volume—but also on the amount of combination of the mixture, which determines the chemical equilibrium of the variable system. The elasticity of such a medium, undergoing simultaneous chemical and physical transformation, may differ from the elasticity of the medium when inert, and consequently the speed of propagation of a disturbance may have a value different from the normal velocity of sound. But this theory requires that a variation in the chemical equilibrium should be produced by infinitely small variations of the volume and temperature, a condition not fulfilled by explosive gaseous mixtures, which can be compressed or raised in temperature to a high degree without any chemical change taking place. So that it is necessary in this case also to assume the creation of a discontinuity in order to explain the high speeds of propagation of explosive phenomena. T. H. P.

2388. *Electric Phenomena in the Euphrates Valley.* **E. Huntington.** (Monthly Weather Rev. 28. pp. 286–287, July, 1900.)—In the little-explored Taurus Mountains, south of Harpoot, peculiar electric phenomena are supposed to occur at rare intervals, perhaps three times in one year, generally in autumn after dry summers, and then not again for several years. They occur on mountains, varying in height between 5,500 and 7,500 feet, situated on both sides of the upper Euphrates, whose bed is about 2,000 feet above sea-level. The district is volcanic; hot springs and extinct craters are still to be seen. Lightning-flashes (or fire-balls) cross the valley between certain pairs of six peaks in either direction, but only between certain peaks, though the river winds a good deal, and the paths are consequently of very unequal length. The author has travelled in the district, but has not himself observed any such phenomena; he is inclined, however, to trust the reports of about a dozen men, living at different places many miles apart, because they agree in their accounts. H. B.

2389. *Fog Studies on Mount Tamalpais (San Francisco).* **A. G. McAdie.** (Monthly Weather Rev. 28. pp. 283–286, July, 1900.)—San Francisco is situated on a peninsula between the Pacific, the Golden Gate, and the Bay of San Francisco; Mount Tamalpais is a few miles to the north of the city. Fogs are regular in the afternoons of the summer months. The temperature on the ocean side may be 55°, and a few miles further inland 110°. The author tabulates meteorological data recorded in the city and on the Tamalpais Observatory, and reproduces three large-size photographs of fogs, streams, and banks. H. B.

2390. *Structure of Grains of Hail.* **P. Czermak.** (Akad. Wiss. Wien, Sitzb. 109. IIa. pp. 185–194, Jan.–March, 1900.)—The author exposed Plateau's drops of water to low temperatures. When water is introduced into a mixture of toluol (density 0·886) and chloroform (density 1·526), with an average density 1, the water assumes the shape of a sphere, which can be rotated if caught on a wire to which a small equatorial disc is fixed. As perfect symmetry is not easily maintained, the drops generally become elliptical, a form often shown by grains of hail. When a large water sphere is broken up into small globules, these latter will not reunite unless a stick of rubbed sealing-wax is approached, or an electric spark made to strike the beaker in which the liquids are contained. If the water is allowed to run down the wire on to the disc, it will freeze to a convex lump, from which icicles project radially, which, with a disc 15 mm. in diameter, may reach a length of 12 mm. in fifteen minutes. These Plateau drops can be considerably under-cooled, especially when small, to — 8° C., with drops 10 mm. in diameter. The author determined the temperature at which crystallisation finally sets in by dipping the point of a thermocouple into the sphere, supporting the latter by a wire ring smaller than the equator of the drop. A crust of ice is formed on the surface, from which needles project into the interior of the sphere. The portion which freezes is much smaller than it looks, only 0·12 of the whole, with drops cooled down to — 10° C., and 0·06 of the whole with drops cooled to — 5° C. This is in accordance with thermal considerations and calorimeter tests which the author made. The peculiar distribution of the air-bubbles in freezing water is also mentioned. H. B.

2391. *Anemometer with Oil Charge.* **A. Feoktistow.** (Zeitschr. Instrumentenk., Beib. 15. pp. 141–143, Aug. 1, 1900.)—The author discusses the difficulties experienced in keeping moisture out of the revolving mechanisms of cup anemometers. At Tajizy, near St. Petersburg, he uses an electric device of Richard Frères, contained in a cast-iron box fixed underneath the cup anemometer. In this device a worm slowly lifts the one arm of a lever to drop it suddenly; the other lever arm then strikes a spring bearing a platinum contact pin which is momentarily pressed against a platinum plate. After much trouble he filled the whole box of 1,400 c.c. capacity with vaselin-oil or petroleum by means of an Alveiler pump. Any water goes down the bend of a pipe, and is, if necessary, withdrawn, together with the oil, once every ten days. The oil does not interfere with the electric contact, and reduces the friction in the gearing, which is more disturbing than the inertia of the parts. He has not ascertained yet, however, whether the oil charge affects the constant of the instrument. The Leclanché cells are filled with calcidum (an ammonium chloride preparation which is said not to evaporate nor freeze). H. B.

2392. *Wind Pressure.* **R. Kohfahl.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1021–1028, Aug. 4, 1900.)—After mentioning that the wind striking against the vertical cliff of Heligoland is deflected in such a manner as to produce a region of calm on the top near the edge, the author criticises the experiments on wind pressure which B. Baker conducted on the Forth Bridge in the years 1884 to 1890. The wind pressure became relatively smaller as the surface (struck normally) was made larger, but not in a regular way. For the relation between the wind pressure against a normal surface and a surface inclined under an angle a, we have five formulæ: the old Prussian architect's rule, von Lössl's, Rayleigh and von Gorlach's, Duchemin's and Hutton's. These formulæ differ considerably from one another, as the author exemplifies by tabulating the pressures for values of a, increasing by 5° from 0° to 90°. He deals particularly with Lössl's formula, $p_1 = p \sin a$, as the simplest and most generally applied, and calculates the forces which would tend to upset right regular prisms. These forces increase with the number of sides of the prism, and attain their maximum value for cylinders, not however in the case of the formulæ of Duchemin and Hutton. The paper then proceeds to reproduce the monthly maxima of wind velocities at Hamburg for the years 1878 to 1898 as recorded by the Seewarte. The highest velocity of 35·6 m. was observed at noon on February 12, 1894. As those figures are derived from hourly averages, the real values were probably higher ; on the other hand, the recent determination of the constants of the instruments would reduce these values. All the great gales came from the S.W. or W.S.W., a few from N.W., hardly any from the E. The maxima for Wustrow, also quoted, situated in the east of Mecklenburg-Schwerin, on the Baltic, are, as a rule, higher (the situation is more exposed), though the Hamburg extreme is not quite reached, and the number of stormy days is greater ; again S.W. winds predominate very strongly. From these figures the author calculates a normal wind pressure of 75 kg./m², and a maximum of 150 kg./m². Allowing further for the partial vacuum to the leeward of a structure, he concludes that pressures of 100 and 200 kg./m² respectively should be considered as normal and maximum for buildings of ordinary size. For high buildings much greater pressures must be allowed for ; on the Eiffel Tower, at an altitude of 303 m., wind velocities have been observed five times as great as at the Central Meteorological Bureau, which has a height of 21·5 m. H. B.

2393. *Elastic Constants of Rocks and Velocity of Seismic Waves.* **H. Nagaoka.** (Phil. Mag. 50. pp. 53–68, July, 1900. Reprinted from the Publications of the Earthquake Investigation Committee in Foreign Languages, No. 4.)—Determination of Young's modulus and the modulus of rigidity of about eighty kinds of rocks. The amount of elastic after-yielding was in most instances very remarkable, and illustrates the folding of rocks. The author gives a tentative application of the results to the velocities of seismic waves, longitudinal and transverse. Deeply embedded rocks are denser and quasi-crystalline, but their coefficient of elasticity tends to assume large values. If the ratio (elasticity ÷ density) reaches a maximum value and then falls off, there will be a stratum of maximum velocity of propagation pretty deep in the earth's crust. Elastic waves must be greatly broken up, reflected, &c., in consequence of non-isotropism and want of uniformity in rocks. The first tremor has almost always a velocity of 13 kilometres per second, which is enormous : 5·3 in a rod of steel, 6·2 in infinite steel, 8·4 in iron pyrites, 9·0 in topaz. The low-lying rocks must have very high elastic constants : say $E = 6 \times 10^{12}$ when the density is 3·5. In iron pyrites $E = 3{\cdot}5 \times 10^{12}$. Between the first tremor and the principal shock comes a disturbance travelling at about 7 kilometres per second, which gives a ratio of lateral contraction to longitudinal extension much the same as that attributed to iron, glass, and other isotropic substances, if we take it that this disturbance is due to a transversal wave in the denser rocks at a depth below the surface. The principal shock travels slowly in surface rocks ; average velocity 3 kilometres per second down to 1 kilometre, according to the rock. It will therefore arrive in successive reverberations according to the rocks it has passed through and the distance it has had to travel, and has been known to run round and round the earth and keep up a tremor for days. A. D.

2394. *Reports of the Earthquake Commission of Vienna. Earthquakes in Austria during* 1899. **E. v. Mojsisovics.** (Akad. Wiss. Wien, Sitzb. 109. 1. pp. 151–313, Jan.–March, 1900.)—Summary of the various reports on earthquake observations throughout Austria (not Hungary) during 1899, chronologically arranged for each of the political divisions of the monarchy. The Commission of the Vienna Academy sends out inquiry sheets, and has interested particularly the schoolmasters and railway officials. The paper reproduces the abridged reports. Carniola and Görz were less disturbed than in previous years, while Dalmatia and Styria were more so than in previous years. The total number of earthquake days was 190, against 209 in 1898. Their distribution over the year was: 22 days in January, 9, 12, 16, 17, 17, 20, 14, 21, 8, 17, 17 in the succeeding months. Most of them occurred in Alpine districts. The district of Sinj in Dalmatia, and the island of Lesina to the south of it, were much alarmed, especially on June 26 and the following days; no serious damage was done, however, anywhere in the state. In Carniola the Save-Laibach basin suffered most, as they did during Easter, 1895; the shocks of September 18 were felt over a length of 150 km. The area of the Tyrolese earthquake of April 5 coincides with the Valsugana cleft. Outside the Alpine districts the disturbances were limited to Upper Austria (especially on June 28), to subterranean detonations in the Duppau Mountains, Bohemia, on August 14; and to tremors at Kladno, Bohemia, on the night of June 3–4; the latter were probably not seismic, but arose in disused mines. There are four seismic stations—at Triest, Kremsmünster, Vienna, Lemberg; the latter two are not quite in working order yet.

The papers in the four following Abstracts refer to reports from some of the districts. The papers are illustrated by maps, not by curves. H. B.

2395. *Earthquakes in Upper Styria in April*, 1899. **R. Hoernes.** (Akad. Wiss. Wien, Sitzb. 108. 1. pp. 617-684, 1899.)—The disturbances of November and December, 1895, increased in 1899, and culminated in the shocks of the three days, April 1, 7, 29; the same districts and localities suffered on these three days; the intensity reached VI, Forel scale. None of these shocks extended into the usually much-disturbed Mürz valley, which leads in a north-easterly direction on to Wiener Neustadt; but they were all felt on the Palten-Liesing line, and particularly to the south-east in the crystalline slates and in the palæozoicum of Graz on the Mur. The latter feature is geotectonically surprising, but the same applies to the Kamp line. The centre seemed to be at St. Stephan, on the Mur (which afterwards changes its north-easterly course to a southerly course), situated some kilometres above Leoben, where many seismic lines intersect. The author recommends erecting an earthquake observatory at Leoben. H. B.

2396. *Earthquakes at Kremsmünster.* **P. F. Schwab.** (Akad. Wiss. Wien, Sitzb. 109. 1. pp. 19–68, Jan.–March, 1900.)—Kremsmünster lies a little south of Linz, in Upper Austria. The whole district is marked with disturbance lines. The paper chronicles earthquakes since 1511, describes the seismological station, which contains a Pfaundler seismoscope and an Ehlert seismograph, and gives detailed reports on the records of the latter instrument for 1899. The maximum for the year falls in the summer months (twenty-one disturbed days in July, not more than four in each month from October to January), and the day maximum in the afternoons. Variations in temperature, wind, and humidity do not explain the records, but barometric depressions, extending over large areas, might do so. H. B.

2397. *Earthquake in Lower Austria, June* 11, 1899. **F. Noë.** (Akad. Wiss. Wien, Sitzb. 109. 1. pp. 71–86, Jan.–March, 1900.)—This local earthquake was confined to the district between Vienna and Wiener Neustadt, which lie near the extremity of the Kamp line of Suess, and the country east of it, as far as the Neusiedler Lake. The seismic centre was near Pottendorf-Landegg, 16 km. N.E. of Wiener Neustadt; the maximum intensity (VI, Forel scale) was at Mittendorf. A large number of shocks were observed between midnight and 4 a.m. H. B.

2398. *Earthquakes at Triest, March to December,* 1899. **E. Mazelle.** (Akad. Wiss. Wien, Sitzb. 109. 1. pp. 89–138, Jan.–March, 1900.)—The paper tabulates the records of the triple horizontal pendulum of Rebeur-Ehlert. From the records taken between September, 1898, and December, 1899, the author finds that August (19·3 days) and February (17 days) are the months of greatest disturbance, and November (14 days) of least. Seismic disturbances are observed about every second day ; amplitudes of 4 mm. and above occur every fourth day, and of 10 mm. every tenth day. The diurnal variations are regular ; the frequency maximum falls in the early afternoon, the minimum about midnight. H. B.

2399. *Velocity of Meteors.* **W. L. Elkin.** (Astrophys. Journ. 12. pp. 4–7, July, 1900.)—The instruments in use at the Yale Observatory, U.S.A., have now been equipped with an arrangement by means of which the velocity of any meteors whose trails are photographed may be determined. Previous suggestions in this direction have been put forward by J. H. Lane in 1860, and by Zenker, of Berlin, in 1885. Quite recently it has again been referred to by Fitzgerald. The apparatus at present installed consists of a bicycle wheel carrying on its periphery a number of opaque screens, so adjusted that on rotating the wheel the lenses of the photographic cameras are covered during certain known periods of time. In actual practice about 30–50 revolutions per minute were obtained by means of a small motor, but the accuracy would be greater if the number of interruptions were increased. The wheel is automatically made to record its rotation on a chronograph barrel for accurate determination of speed. Two sets of apparatus must be employed at stations some distance apart. The Yale experiments were made at places about 3 kilometres apart. Examples are given of the deduced velocities of five duplicate trails already photographed, showing speeds from 32–40 kilometres per second with respect to the sun. C. P. B.

2400. *Suggested Explanation of the Solar Corona.* **J. Scheiner.** (Astrophys. Journ. 12. pp. 25–29, July, 1900.)—The absence of the dark Framhofer lines in the spectrum of the corona indicates that that structure cannot derive its light to any considerable degree from reflected sunlight. The idea that the coronal radiation may be due to the friction of meteoric matter falling into the sun is unlikely, considering the undoubted low density of the coronal matter. If the temperature assumed by a small perfectly black body at a certain distance from the sun's surface be calculated, values are obtained which have much probability of truth.

If q = quantity of heat radiated by an element of solar surface in unit of time,
ϕ = apparent semi-diameter of sun,

then the integral of the radiation upon an elemental area perpendicular to the line of sight will be—

$$W = \pi q \sin^2 \phi.$$

According to the most recent determinations the quantity of radiation received by the earth per minute per sq. centimetre is—

$$W = 4{\cdot}0 \text{ gramme calories, where } \phi = 16'.$$

At the distance corresponding to the outer ring of the corona the sun's semidiameter would be about 45°, so that here the radiation received would be—

$$W = 4 \times 23083 = 92{,}332 \text{ gramme calories.}$$

Calculating the effective temperature, obtaining when the stationary condition is reached, from Stefan's law—

$$W = \sigma . T^4,$$

where T is the absolute temperature, and σ a constant whose value has been recently determined accurately by Kurlbaum as—

$$\sigma = 1{\cdot}28 \times 10^{-12} \text{ (unit of time} = 1 \text{ second).}$$

Hence the stationary temperature of an absolutely black unit of surface at the outer edge of the corona would be about—

$$T = 5890^\circ.$$

Correcting this for the fact that the receiving surface would not be plane, but approximately spherical, we get—

$$T = 4160^\circ.$$

This would be the extreme upper limit. Other constants might be used, involving the assumption of an existing atmosphere, but even in this case the effective temperature does not fall below 1,530°, and as this is still considerably above the temperature of incandescence, the author thinks there is no occasion to seek for any other cause of the continuous spectrum of the corona other than that of the direct radiation of the solar photosphere itself on an assumed collection of minute bodies in the region surrounding it. C. P. B.

REFERENCES.

2401. *Quick-working Mercury Pump.* **Berlemont** and **Jouard.** (Comptes Rendus, 131. pp. 110–111, July 9, 1900; also Soc. Franç. Phys., Bull. 152. pp. 3–4, 1900.)

2402. *Ether Problems.* **J. Larmor.** (Elect. Engin. 26. pp. 339–341, Sept. 7, and 384–388, Sept. 14, 1900.)—The Presidential Address delivered before the Mathematical and Physical Section of the British Association.

2403. *Physical Tables.* (Bureau des Longitudes, Ann. pp. 487–628, 1900.)—A selection of useful tables, with explanations by **Damour, Berthelot, Cornu, Sarrau,** and others. A. D.

2404. *Scales of Seismic Intensity.* **C. Davison.** (Phil. Mag. 50. pp. 44–53, July, 1900.)—A careful comparison of the various scales of seismic intensity which have been proposed, and of the requisites of such scales. A. D.

2405. *Seismometrograph.* **G. Agamennone.** (Accad. Lincei, Atti, 9. pp. 31–39, July 15, 1900.)—Description of a new instrument of the horizontal pendulum type with a half-ton bob, and multiplying gear for the writing-point. A. D.

2406. *Solar Eclipse, May* 28, 1900. (Astrophys. Journ. 12. pp. 58–102, July, 1900.)—This paper gives in a condensed form the preliminary reports of the various observers occupying American stations during the late eclipse. Details of instrumental equipment, exposure, and many reproductions from the photographs obtained accompany the article. C. P. B.

LIGHT.

2407. *Relation of Brightness and Temperature.* **O. Lummer** and **F. Kurlbaum.** (Deutsch. Phys. Gesell., Verh. 2. 8. pp. 89–92, 1900.)—The radiation from a hollow platinum vessel is, with that of a platinum strip, passed through separate lenses on to the two faces of a Lummer-Brodhun photometer, the two platinums being made luminous by means of electric currents. The temperature of the hollow vessel is measured by a thermo-element when equal brightness is attained. Then, by means of a rotating sector, the brightness of the hollow vessel is diminished by a known amount, and photometric equality again obtained by raising the temperature of the vessel. If H_1, H_2, are the brightnesses of the hollow vessel at the respective absolute temperatures T_1, T_2, $\frac{H_1}{H_2} = \left(\frac{T_1}{T_2}\right)^x$, x depending on the temperature. The following values of x are found :—

T. abs.	900	1,000	1,100	1,200	1,400	1,600	1,900
x	30	25	21	19	18	15	14

The authors intend to determine the function x for a black surface; and then, by comparing both black and platinum surfaces with the sun, photometrically, an estimate of the sun's temperature can be made. G. E. A.

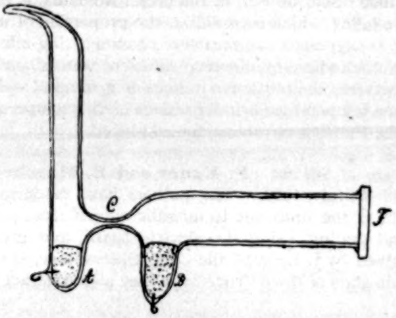
2408. *Scintillation and Atmospheric Currents.* **K. Exner.** (Akad. Wiss. Wien., Sitzb. 109. IIa. pp. 170–184, Jan.–March, 1900.)—A review of the researches of various physicists on the relation between atmospheric currents and scintillation, concluding with an account of several experiments by the author. The view is held that in the light from the fixed stars the wave-front is slightly disturbed from its plane form. Hence the rays, though but slightly changed from parallelism, pursue a wavy course and are at different places more or less closely packed in the beam than if not so disturbed. Thus a fluctuation of intensity arises. E. H. B.

2409. *Colour Screen for Telescopes.* (Scientific American, 83. p. 186, Sept. 22, 1900.)—This is a small apparatus, due to T. J. J. See and G. H. Peters, which has been used to cut off some of the outstanding secondary spectrum from the images of celestial objects as seen with telescopes only corrected for two of the spectrum colours. Various combinations of coloured liquids were enclosed in a small glass tank placed between the eyepiece and the eye. Bichromate of potash, picric acid and chloride of copper, chromate of potash, and chromic acid were experimented with, the second solution yielding most satisfactory results. C. P. B.

2410. *Refractive Index and Alcohol-Solvent Power of Clearing and Mounting Media.* **C. E. M'Clung.** (Chem. News, 82. p. 88, Aug. 24, 1900. From the Kan. Univ. Quarterly, 7. No. 4.)—A table is given of the refractive indices (for sodium light) and clearing powers of a large number of oils and other liquids used in microscopy; the clearing powers given represent the lowest strengths soluble in the reagent. Prices are also given where obtainable. Attention is called to oil of cassia, which has a refractive index 1·60160, clears from 80 per cent. alcohol, and dries hard enough to make permanent mounts. T. H. P.

2411. *Physiological Cold Light.* **R. Dubois.** (Comptes Rendus, 131. pp. 475–477, Aug. 27, 1900.)—The author obtains light by bacteria in suitable liquids. Such light has the well-known advantage that it is free from heat waves, and also has but slight chemical effect. The liquids should contain water, sea salt, glycerine or mannite, a nitrogenous body such as peptone or asparagine, and a compound of phosphorus such as lecithin or potassium phosphate. Asparagine is preferable to the peptones because there is less tendency to fermentation. No information is given as to the bacteria. The permanence of the light depends on the richness of the liquids, aeration, agitation, purity and temperature. It may continue for six months. The author has obtained illumination equal to strong moonlight. W. R. C.

2412. *Vacuum Tube with Mercury Electrodes for Zeeman Effect.* **F. Paschen.** (Phys. Zeitschr. 1. pp. 478–480, Aug. 4, 1900.)—The vacuum tube was designed to obtain an intense source of light for the special study of the complicated Zeeman effect observed by Michelson in the case of the mercury lines 5461 and 4359. The tube consists of a vertical and a horizontal portion (see diagram), at the junction of which two mercury cups A and B are connected by means of a capillary portion C. The bright line produced in C is viewed end-on through the plate of fluorspar F. The cup representing the kathode is warmed so as to produce the proper pressure of mercury vapour. The constriction C is made to fit exactly between the rounded pole-pieces of an electromagnet. When the field is excited the line of light joining the electrodes increases greatly in brightness, and even surpasses in that respect the brilliance of a helium tube. Since no foreign gas is contained in the tube, the mercury remains perfectly clean. The life of the tube is, however, not very long, as it usually cracks near the anode after five or ten hours' use. E. E. F.



2413. *Compound Zeeman Effect.* **C. Runge** and **F. Paschen.** (Phys. Zeitschr. 1. pp. 480–481, Aug. 4, 1900.)—With the vacuum tube described in the previous Abstract, the authors have observed the complicated Zeeman effect first described by Michelson. The green mercury line 5461 shows three central components whose electric oscillations are parallel to the lines of force. Then follow on both sides four further components, whose intensities decrease outwards, and whose oscillations are at right angles to the direction of the lines of force. Thus the single line is split up into eleven components. The line 4359 is split up into eight components. These two lines, 5461 and 4359, form two components of a triplet whose third component lies at 4047. It was therefore interesting to inquire whether a corresponding Zeeman effect could be obtained in the case of the third line. That was found to be the case. The next triplet of the series is formed by the lines 3341·7, 2893·7, and 2752·9. In the magnetic field they show the same modifications, and in the same succession, as the first triplet, except that in the first of them the extreme lines are no longer visible. In corresponding lines of each triplet the difference of frequencies is the same. E. E. F.

2414. *Focal Surfaces in Photographic Objectives.* **H. Harting.** (Zeitschr. Instrumentenk. 20. pp. 234–237, Aug., 1900.)—The author here criticises a paper by Wanach [Zeitschr. Instrum. 20. p. 161, 1900; Abstract No. 2175 (1900)], dealing, among other things, with the astigmatic focal surfaces in photographic objects. He also gives a solution of the problem by using Czapski's method, which he considers very much better than that used by Wanach. J. B. H.

2415. *Refractometry of Mineral Waters.* **E. Riegler.** (Chem. News, 82. p. 78, Aug. 17, 1900; Soc. de Sci. d. Bucuresci Romania, 9. p. 251, Nos. 2–3.) —The refractive index, which increases as the proportion of solid matter in a water increases, is suggested as a means of characterising mineral waters. A table is given of the indices of nineteen different waters, and it is found that the difference between the refractive indices of a mineral water and of pure water at the same temperature is independent of this temperature and of the adjustment of the Pulfrich refractometer employed. T. H. P.

2416. *Spectrum of Silicon.* **F. Exner** and **E. Haschek.** (Astrophys. Journ. 12. pp. 48–49, July, 1900.)—The authors have made measurements of the wave-lengths of the lines due to metallic silicon from photographs with a large Rowland grating, using the electric spark, and give values which confirm those given by J. Lunt, of the Cape Observatory, as occurring in the spectra of certain stars of the β Crucis type [see also Abstract No. 998 (1900)]. C. P. B.

2417. *Spectrum of Radium.* **E. Demarçay.** (Comptes Rendus, 131. pp. 258–259, July 23, 1900.)—A specimen of very pure radium, with barium lines very feeble, gave no lines beyond those already found [Abstract No. 55, (1900)], but some weak nebulous rays are much better marked. The spectrographic characters of radium are similar to those of the alkaline earths. A. D.

2418. *Spectra of Mercury.* **W. B. Huff.** (Astrophys. Journ. 12. pp. 103–119, Sept., 1900.)—The author has made a systematic study of the various spectra given by mercury vapour under different conditions, the importance of which had been suggested by previous work by Lewis on the effects of impurities in gaseous spectra [Abstracts Nos. 468 and 1793 (1900)]. Photographs were obtained with concave gratings of 21 feet and 7 feet radius. The arc spectrum was given by a direct current of about 10 amperes, while the spark and tube discharges were actuated either by an 8 cm. spark induction coil, or from a coil carrying alternating current in its primary from a Westinghouse dynamo making 130 complete oscillations per second. German soda-glass was used for the vacuum tubes. Numerous photographs are given showing the effect of introducing self-induction into the secondary spark circuit. C. P. B.

2419. *Lamps for Spectrum Analysis.* **E. Beckmann.** (Zeitschr. Phys. Chem. 34. pp. 593–611, Sept. 7, 1900.)—The author describes a new arrangement for obtaining coloured flames for spectroscopic work. The method employed consists in forcing air through the pores of a porcelain tube immersed in a solution of the salt to be examined, the finely divided gas impregnated with the solution then passing through a Bunsen flame. The vessel containing the solution is arranged between two burners placed obliquely so as to give a vertical flame above the surface of the liquid. With aqueous solutions the pressure necessary to force the air through the porous tube into the liquid is from 1·6 to 2 atmospheres, but with liquids having less surface tensions such as alcohol, acetone, or acetic acid, about half the above pressure suffices. A detailed description is given of the apparatus, which is now on the market. Another method of obtaining a stream of fine gas particles is by the electrolysis of the salt solution, but the difficulties of working have not yet been overcome in a satisfactory manner.

T. H. P.

2420. *Velocity of Ions Produced by Röntgen Rays.* **J. Zeleny.** (Roy. Soc., Proc. 66. pp. 238–241, April 14, 1900. Also Roy. Soc., Phil. Trans. 195. pp. 193–234, Nov. 9, 1900.)—The velocity is determined for the positive and negative ions by comparing the ionic velocity directly with that of a stream of gas flowing between two concentric cylinders at different potentials, a narrow beam of Röntgen rays being passed through the cylinders at right angles to their length. The results given are reduced to a pressure of 760 mm. of mercury, but are not corrected for temperature, the effect of which is unknown.

Gas.	Velocity in cms. per sec. in a field of 1 volt per cm.		Velocity in cms. per sec. in a field of 1 E.S.U. per cm.		Ratio of negative to positive.	Temperature.
	+	−	+	−		
Air, dry	1·36	1·87	408	561	1·375	13·5 C.
Air, moist	1·37	1·51	411	453	1·100	14
Oxygen, dry	1·36	1·80	408	540	1·320	17
Oxygen, moist	1·29	1·52	387	456	1·180	16
Carbonic acid, dry	0·76	0·81	228	243	1·070	17·5
Carbonic acid, moist	0·82	0·75	246	225	0·915	17
Hydrogen, dry	6·70	7·95	2,010	2,385	1·190	20
Hydrogen, moist	5·30	5·60	1,590	1,680	1·050	20

G. E. A.

2421. *Production of Röntgen Rays.* **A. Winkelmann.** (Ann. d. Physik, 2. 4. pp. 757–767, Aug., 1900.)—When a spark-gap is introduced into a Röntgen ray circuit, the maximum gaseous pressure at which Röntgen rays can be produced is increased. The author shows that the maximum pressure attainable depends upon the length and position of the spark-gap, the nature of the gas, and the dimensions of the tube. At the highest pressures, Röntgen rays only appear when the spark-gap lies between the kathode and the induction coil. As the pressure decreases, rays begin to appear also when the spark-gap is next the anode, but they are feebler than in the other arrangement. At low pressures, the influence of the position of the spark-gap becomes less pronounced and finally disappears. Hydrogen yields Röntgen rays at greater pressures than air or carbonic acid. The latter allows the least pressure, but its difference from air in this respect is not great. The admissible pressure may be considerably increased by making the tube narrower. Thus in a tube only 5 mm. in diameter it was found possible to increase the pressure of the air contained in it to 10 mm. of mercury and yet obtain effective Röntgen rays. But a further narrowing has the contrary effect, and in hydrogen the maximum pressure of 30 mm. is already reached in a tube 1 cm. in diameter. E. E. F.

2422. *Becquerel and Röntgen Rays.* **F. Himstedt.** (Phys. Zeitschr. 1. pp. 476–478, Aug. 4, 1900.)—The experiments described were chiefly made with one of Giesel's radium preparations. The author was able to demonstrate the influence upon an electroscope exerted by the preparation at a distance of 5 m. through the iron walls of the containing box. The stoppage of the play of sparks in a spark-gap attached to an influence machine was also strikingly shown. Röntgen rays produce the same effect, even at a distance of 4 m. To investigate the origin of radium rays, the author examined the behaviour of the preparation at the temperature of liquid air. But no diminution either of the effect upon a fluorescent screen or upon the discharging action was discovered, whereas Balmain's luminous paint was completely extinguished under the same circumstances. A number of experiments upon the visual perception of Becquerel rays showed that the perception of the rays is subject to rapid fatigue, probably owing to a continuous subsequent fluorescence of the humours of the eye. Blind people see the rays distinctly unless their retina is paralysed. Becquerel rays, Röntgen rays, and ultra-violet rays all reduce the resistance of a solenium cell. This is not due to the fluorescence of the latter, as no such fluorescence could be perceived. E. E. F.

REFERENCES.

2423. *Three Lens Objective for Telescope or Microscope.* **H. Harting.** (Zeitschr. Instrumentenk. 20. pp. 230–234, Aug., 1900.)—This paper forms another of the series of papers by the same author on the calculation of lenses for particular objects [see Abstracts Nos. 1844 (1899), 465 and 835 (1900)]. The present one deals with a three lens objective, the first and third lenses being of the same glass. J. B. H.

2424. *Ultra-violet Spark Spectra.* **F. Exner** and **E. Haschek.** (Akad. Wiss. Wien, Sitzb. 109. IIa. pp. 103–169, Jan.–March, 1900.)—The authors continue their examination of scandium and samarium [see Abstract No. 1993 (1900)]. S. R.

HEAT.

2425. *Vapour Pressure of Mercury.* **W. Müller-Erzbach.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 127-136, 1900.)—Mercury in glass cylinders was placed in a widely open cupboard in a quiet room. Its surface thus remained clear for weeks. By finding the loss of weight and comparing this with the loss of weight of water under similar conditions the vapour pressure of the mercury was calculated, using a development of Graham's diffusion law, viz. :—

$$\frac{w_1}{w_2} = \frac{p_1}{p_2}\sqrt{\frac{d_1}{d_2}}$$

Where w_1, w_2 are the weights of evaporated liquids, p_1 and p_2 their vapour pressures, and d_1, d_2 their vapour densities.

Temp.	Duration of Experiment.	Loss of Weight.	Daily Loss of Weight.		Vap. Press. of Hg.
			Hg.	H_2O.	
	Days.	mg.	mg.	mg.	mm.
13·5	121	26	0·215	595	0·00124
14·5	30	7	0·233	651	0·00131
14·9	62	16	0·258	661	0·00147
16·6	41	14	0·341	726	0·00197
17·9	17	5	0·323	762	0·00193

The result for 16·6° is considered the best, and other observers' results are appended, the paper containing also the discussion of a number of results for other liquids. G. E. A.

2426. *Thermal Conductivity of Gases.* **P. A. Eckerlein.** (Ann. d. Physik, 3. 1. pp. 120-154, Sept., 1900.)—The thermal conductivities of air, hydrogen, and carbonic acid at low temperatures were determined by means of the thermometer method, the thermometric substance being petroleum ether. For air the conductivity k at $-59°$ was found to be 0·00003678 g/cm. sec., whereas k_{-150} was 0·00002146. From these two values we obtain $k_0 = 0{\cdot}00004677$ as against the latest theoretical value 0·0000455. For hydrogen the values were—

$$k_{-50} = 0{\cdot}0002393$$
$$k_{-150} = 0{\cdot}0001175$$
$$k_0 = 0{\cdot}0003186.$$

For carbonic acid, the value found was—

$$k_{-50} = 0{\cdot}00002645.$$

By Maxwell's law, which is known to hold good for CO_2, the value for k_0 would be 0·00003384. The experimental value is 0·00003434, thus showing a fair agreement. The conductivities of air and hydrogen do not increase in a linear manner from the absolute zero to ordinary temperatures, but the temperature coefficient gradually decreases, probably owing to molecular changes. In general, it may be said that Maxwell's theory is in good agreement with the facts. It is specially corroborated by the behaviour of carbonic acid at low temperatures. E. E. F.

2427. *Influence of Molecular Volume on Gaseous Viscosity, II.* **G. Jäger.** (Akad. Wiss. Wien, Sitzb. 109. IIa. pp. 74–80, Jan.–March, 1900.)—In the formula for the viscosity, $\eta = k\rho c\lambda$, λ represents the path over which a molecule carries a definite amount of momentum. If the molecules may be taken as perfectly elastic they interchange their momenta on collision, so that λ exceeds the mean free path by a magnitude which at most equals the diameter s of a molecule, and which, by an approximate calculation wherein the speeds of all the molecules are taken as equal, the author finds to be $\frac{1}{2}s$ in the mean. Thus for the formula given in Abstract No. 75 (1900) we must write—

$$\eta = k\rho c\,(1 + 4\beta A)\,(\lambda_0 A^{-1} + \tfrac{1}{2}s),$$

where $A \equiv 1 + \frac{5}{8}\beta + \ldots$; and since $\lambda_0 = 3/4N\pi s^2$, $\beta = \frac{1}{6}N\pi s^3$, this becomes—

$$\eta = \eta_0\,(1 + 4\beta A)^2/A.$$

Hence for moderate densities the viscosity is $\eta_0(1 + \frac{11}{2}\beta)$, but for the liquid state it approximates to ∞, since A is then very large. R. E. B.

2428. *Law of Cailletet and Mathias and the Critical Density.* **S. Young.** (Phil. Mag. 50. pp. 291–305, Sept., 1900. Paper read before the Physical Society of London.)—Thirty substances have been examined by the author in order to test the law of the rectilinear diameter, due to Cailletet and Mathias, which states that the means of the densities of liquid and saturated vapour for any stable substance are a rectilinear function of the temperature. He has determined their mean densities at intervals of temperature of 10° between 0° and their boiling-points, as well as for higher temperatures. He finds that the law is nearly true, but not strictly true unless the ratio of the actual (D_c) to the theoretical (D'_c) density at the critical point has the normal value 3·77, as determined by Meyer's correction of the estimate of van der Waals. The formula $D_t = D_0 + \alpha t + \beta t^2$, where D_t, D_0 are the mean densities at $t°$ and 0°, and α, β are constants, is more accurate, and the values of α and β are determined for the thirty substances; for certain alcohols, however, it is necessary to introduce a fourth term, γt^3. The curvature of the "diameter" is generally smaller, the nearer D_c/D'_c approaches the normal value, β being positive when D_c/D'_c is less than 3·77, and negative when D_c/D'_c is greater than 3·77, α being always negative. The curvature is so slight that the critical density may be calculated from the mean densities at temperatures from about the boiling-point to near the critical point by the simple formula $D_t = D_0 + \alpha t$ with small error; but if it be calculated by this formula from the mean densities below the boiling-point the error may be considerable, probably 5 or 6 per cent. for normal decane. The critical densities of the thirty substances, as calculated from the new formula, are given. As Guye has pointed out, the law does not hold at all for substances whose molecules differ in complexity in the gaseous and liquid states [see also Abstract No. 262 (1899)]. W. E. T.

2429. *Thermal Diffusivities of Marble.* **B. O. Peirce** and **R. W. Willson.** (Amer. Acad., Proc. 36. pp. 13–16, June, 1900.)—Determinations of the thermal conductivities of different kinds of marble were made by the so-called "wall method." The horizontal bases of a rectangular prism of height small compared with the area of a horizontal cross section were kept for a long time at constant temperatures, the final temperatures at two or more points in the vertical axis were determined, and the flux of heat through a definite central portion of the colder base was measured. Besides the conductivities, the authors have also measured the specific heats of the different specimens tested, and their results are given in the following table :—

	Sp. gr.	Conductivity.	Avg. Sp. Heat (25° to 100°).	Sp. Heat per unit vol.	Diffusivity.
Carrara	2·72	0·00505	0·214	0·579	0·0087
Mexican Onyx	2·71	0·00556	0·211	0·572	0·0094
Vermont Statuary	2·71	0·00578	0·210	0·569	0·0102
American White	2·72	0·00596	0·214	0·582	0·0102
Egyptian	2·74	0·00623	0·212	0·581	0·0107
Sienna	2·68	0·00676	0·215	0·576	0·0117
Bardiglio	2·69	0·00680	0·218	0·586	0·0116
Vermont Cloudy White	2·75	0·00681	0·210	0·578	0·0118
Vermont Dove Coloured	2·74	0·00684	0·208	0·570	0·0120
Lisbon	2·75	0·00685	0·211	0·580	0·0118
American Black	2·68	0·00685	0·214	0·574	0·0119
Belgian	2·75	0·00755	0·206	0·567	0·0133
African Rose Ivory	2·75	0·00756	0·212	0·583	0·0130
Tennessee Fossiliferous	2·71	0·00756	0·214	0·580	0·0130
Knoxville Pink	2·73	0·00757	0·212	0·579	0·0131
St. Baume	2·70	0·00761	0·210	0·567	0·0134

J. J. S.

2430. *Radiation of a Black Body.* **O. Lummer** and **E. Pringsheim.** (Ann. d. Physik, 3. 1. pp. 159–160, Sept., 1900.)—In 1897 the authors had referred their thermoelectric measurements of the radiation of a black body to Holborn and Wien's normal couple. They have now reduced the temperatures to Holborn and Day's nitrogen thermometer [Abstract No. 2003 (1900)], and give a new table of temperatures of black bodies. E. E. F.

2431. *Heat-conduction within the Earth.* **J. Schubert.** (Phys. Zeitschr. 1. pp. 442–445, July 14, 1900.)—Riemann's theory is tested by comparison with the results of observation at Eberswalde and four other stations, the lag in phase of the "soil-heat below a depth" (defined by the integral $\int_x^\infty c\vartheta\, dx$, where ϑ is the temperature at the depth x and c is the specific heat of the soil per unit volume) behind the temperature at that depth being especially considered. In the theory c is assumed to be constant, but it must really vary with the season as well as with the character of the ground where the observations are made. Allowance, however, being made for this, the results of the comparison are satisfactory. R. E. B.

2432. *Theory of the Constant-volume Gas Thermometer.* **J. Rose-Innes.** (Phil. Mag. 50. pp. 251–260, Aug., 1900.)—The ordinary theory of the constant-volume thermometer introduces an arbitrary function of the pressure by integration along an isopiestic, which is determined by extrapolation to infinity from observations made in a small range. The author of this paper avoids the necessity for extrapolation by transforming the usual differential equation before integration. The formula arrived at is applied to the determination of the absolute value of the freezing-point of water, integration being effected between the limits of temperature, 0° C. and 100° C. The numerical data are taken from the recent determinations by Chappuis of the increase of pressure of hydrogen at constant volume between these limits of temperature, from the measurements by Joule and Kelvin of the heating effect occurring when hydrogen passes through a porous plug, and from the determinations by Amagat of the relation between pv and p for hydrogen at constant temperature. The value thus found is in close agreement with the estimate derived by Kelvin from the constant-pressure air-thermometer.

In the case of hydrogen, nitrogen, and air the transformed differential equation is simplified by means of the characteristic equation of a perfect gas, the error thus introduced being shown to be only of the order of squares of small quantities; and the condition then is found that the constant-volume thermometer should give readings in accordance with the thermodynamic scale. The author also deduces the characteristic equation of a nearly perfect gas in the form—

$$p=\frac{Rt}{v-B}-\frac{\lambda}{v^2}$$

R, B, and λ being constants.

Attention is directed to the difference in theory between the methods of Joule and Kelvin of testing Mayer's hypothesis. The transformed differential equation of the paper exhibits the latter theory in a precise manner, and shows that the hypothesis would have been actually disproved if no change of temperature had occurred in the gas which passed through the porus plug.

W. E. T.

2433. *A Theorem Analogous to the Virial Theorem.* **Rayleigh.** (Phil. Mag. 50. pp. 210–213, Aug., 1900.)—The author, confining himself to the case of two dimensions, shows that, if m be the mass of the particle at the point x, y, and X, Y the components of force acting upon it, in any system—

$$2\Sigma m\frac{dx}{dy}\frac{dy}{dt}=\frac{d^2}{dt^2}\Sigma(mxy)+\Sigma(xY+yX),$$

the summation extending over all the particles of the system. Or, taking mean values with respect to time, if $\frac{d}{dt}\Sigma(mxy)$ does not continually increase, he obtains as in the case of the virial theorem—

$$2\Sigma m\frac{dx}{dt}\frac{dy}{dt}=\Sigma(xY+yX).$$

This equation seems applicable to the molecular theory of the viscosity of gases.

For statical problems it is of advantage to state the theorem in the following form:—In any system in equilibrium, if X, Y be the components of the total *external* force acting on the particle at the point x, y, and R be the force mutually operative between the particles at x, y and x', y', ρ being the distance between these particles and ϕ the inclination of ρ to the axis of x,

$$\Sigma(xY+yX)+\Sigma R\rho\sin 2\phi=0,$$

where the first summation extends to every particle and the second to every *pair* of particles.

Illustrations of the application of the theorem to frameworks are given and its utility in hydrostatical problems pointed out, the forces exercised by the containing vessel upon a liquid confined under hydrostatic pressure contributing nothing to the left-hand member of the equation. W. E. T.

2434. *Two Remarkable Groups of Geometrical Loci on the pv-Diagram.* **E. Mathias.** (Journ. de Physique, 9. pp. 479–487, Sept., 1900.)—From his experimental results for CO_2 Amagat has found that the locus of the points on a pv-diagram representing unit mass of the liquid and saturated vapour in equal volumes is a rigorously straight line nearly perpendicular to the v-axis. Mathias, *assuming* that the law of the straight diameter is exact (*i.e.*, that the mean of the densities of the liquid and saturated vapour for any the same temperature is a linear function of the temperature), concludes that Amagat's result is only approximate, and that the locus is really a curve A which is everywhere concave to the origin. [We might therefore, on the contrary, take Amagat's result as indicating that for CO_2 the law of the straight diameter is only approximate.]

Another result of the law of the straight diameter is that, of all the curves representing unit mass of liquid and saturated vapour in a constant mass-ratio, that one B alone meets the curve of saturation at a finite angle which corresponds to equal masses of liquid and vapour, and that this is convex towards the origin and touches the curve A at the critical point. This is true also for a certain other curve which is without physical signification, and the three corresponding curves on a $t\rho$-diagram are analogously related. R. E. B.

2435. *Entropy Theory.* **J. E. Trevor.** (Journ. Phys. Chem. 4. pp. 514–528, June, 1900.)—The author calls attention to the relation between the thermodynamic temperature and the entropy of a system in the case of reversible additions of heat, as in all respects analogous to the potential theory in mechanics. He refers to a former paper of his own in the Journ. Phys. Chem. 3. p. 339, 1899 [Abstract No. 68 (1900)], in which he says he failed to establish the existence either of a uniquely determinate thermal potential or of the entropy function of any given thermodynamic system. In the present paper these results are obtained.

He first explains "the level theory," using a series of Carnot cycles, each of which may correspond to a given amount of work done or of heat used. The thermal potential corresponds to the energy of position in dynamics. The two principal definitions suffice to show the general nature of the reasoning.

Definition I.—The difference of thermal potential, corresponding to the difference of two given temperatures, shall be measured by the number of equal-work Carnot cycles in any series between the two temperatures.

Definition II.—The changes of "heat weight," or entropy of a system, shall be measured by the total work-value of the one-degree Carnot cycles, that correspond to the systems' simultaneous absorption of heat. Using θ to express the thermal potential as above defined, and η to represent the "heat weight" or entropy as above defined, he obtains finally the energy equation—

$$dE = dW + \theta d\eta,$$

where E denotes energy and W work. S. H. B.

REFERENCE.

2436. *Heat and Molecular Motion.* **Holzmüller.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1080–1087, Aug. 18, 1900.)—The ordinary elementary explanation is here given of the phenomena of emission and absorption, and the elements of the kinetic theory of gases are also treated. J. B. H.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

2437. *Theory of Potential.* **F. Hasenöhrl.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 1667–1698, 1899.)—The problem of finding the value of the potential at all points in space, when its value is given at each point on the surface of each of two spheres external to each other, was solved by Kelvin, who used the method of electric images. Hasenöhrl here treats the same problem by the older, or Murphy, method of spherical harmonics. Let the common diameter of the two spheres be taken for axis. Let a, a' be their radii, r, r' the distance of any point from their respective centres. Then, if P be a point external to both spheres, the potential at P due to any distribution which has the given potential V_a at all points on the sphere a can be expressed in the form—

$$\sum_{\mu=0}^{\mu=\infty} S\mu\left(\frac{a}{r}\right)^{\mu+1},$$

where $S\mu$ is a spherical surface harmonic of order μ, zonal about the common diameter. A similar expression holds for either sphere. Therefore—

$$V=\sum_{\mu=0}^{\mu=\infty} S\mu\left(\frac{a}{r}\right)^{\mu+1}+\sum_{\mu=0}^{\mu=\infty} S'\mu\left(\frac{a'}{r'}\right)^{\mu+1}+Q_1$$

Here Q_1 must satisfy Laplace's equation at all points external to both spheres, and at any point on the surface of either sphere must have an equal and opposite value to that due at the same point to the other sphere. Hasenöhrl now uses Q_1 for V, and so derives a new function Q_2 and so on. And by this means obtains the required function V in a convergent series. S. H. B.

2438. *Illustration of Poynting's Theorem.* **G. Mie.** (Zeitschr. Phys. Chem. 34. pp. 522–528, Sept. 7, 1900.)—The equipotential surfaces of electric force near a cylindrical conductor carrying a steady current are shown as long truncated cones surrounding the wire. The Poynting vector, viz., energy flowing per unit area per sec. =

$$\frac{\text{elec. motive intensity} \times \text{magn. intensity} \times \text{sine included angles}}{4\pi},$$

is then evaluated for a loop conductor passing through a plane, and is shown to be equal to the product of the current × the potential difference of the two points where the loop passes through the plane.

The case is then worked out of two parallel equal wires of great length, one pair of ends being at zero potential. Expressions are found for the electric and magnetic potentials and figures are given showing equipotential lines of electric and magnetic force in a section perpendicular to the wires, and the lines of flow of energy in a plane through the axis of the wires. Full particulars of the data used in the construction of the curves are given, and the author concludes that, especially for alternate currents, the Poynting theorem is necessary for a clear understanding of the electromagnetic processes. G. E. A.

2439. *Thermo-electric Theory.* **W. Voigt.** (Ann. d. Physik, 3. 1. pp. 155–158, Sept., 1900.)—The author criticises Liebenow's theory of the connection between thermal and electric currents [see Abstract No. 2016, (1900)]. He acknowledges that Liebenow's theory is in striking agreement with the facts, but that is only a kind of negative evidence for its truth. The chief objection to Liebenow's theorem lies in the ambiguity of the sign. In other theories where such an ambiguity occurs, it is due to the unknown numerical values of certain parameters. But in Liebenow's theorem the signs and values of all the constants are known, and yet there is an ambiguity of sign. Such a case is without a precedent in physics. E. E. F.

2440. *Elongation of Dielectrics in an Electrostatic Field.* **L. T. More.** (Phil. Mag. 50. pp. 198–210, Aug., 1900.)—Former experimenters on the change in length and volume of a dielectric when in an electrostatic field have always observed definite changes to take place, and some of them have represented these changes by formulæ. Röntgen in discussing the experimental results of Righi, Quincke, and others, and comparing them with his own, attributes the observed changes of volume and length to the electric compression of the electrodes and the heating effect of the electric charge. The present author has made careful experiments on the change of length, and has observed none to take place beyond the limits of experimental error, and certainly none approaching the changes of length observed by former experimenters.

The dielectrics used were glass and hard rubber tubes. The tube was placed between, and coaxial with, two vertical brass tubes. The three tubes were joined at the bottom by insulating material, and the spaces between them were filled with a liquid dielectric, having approximately the same specific inductive capacity as the glass or rubber tube being experimented on. This gave a uniform potential gradient between the two brass tubes, and so avoided any surface charges on the glass or rubber. The change of length was observed by means of a small optical lever, resting with two feet on the top of the inner brass tube, and with the third foot on the glass tube. One division of the micrometer eyepiece employed corresponded to a change of length of $1{\cdot}5 \times 10^{-5}$ mm., and quarter divisions could be read. Differences of potential of about 33,000 volts were used, and when the apparatus was adjusted so that no lateral motion of the top of the tube took place no elongation or contraction was detected.

It being supposed that the potential was not great enough, it was resolved to confirm the experiments of former investigators. The outer brass cylinder was removed, the space between the glass and inner brass cylinders was filled with acidulated water, and the middle of the outer surface of the glass cylinder covered with tinfoil. In no case was any elongation or contraction observed. A comparison with Righi's results shows that an elongation of at least ten divisions should have occurred.

The author attributes the experimental discrepancies to the methods used by Righi, Quincke, and others. The changes which these experimenters have observed he attributes to lateral distortions being recorded as changes in length owing to the system of rigid mechanical levers employed for magnifying. The author was greatly troubled by these lateral distortions and bendings, but they were always detected by a lateral motion of the field taking place simultaneously with the up-and-down motion.

The changes in volume which have been observed in liquid dielectrics, he attributes to changes in the form of the thermometer bulbs. J. B. H.

DISCHARGE AND OSCILLATIONS.

2441. *Pressure in the Electric Spark.* **E. Haschek** and **H. Mache.** (Astrophys. Journ. 12. pp. 50–51, July 1900.)—The authors reply to the criticism advanced by J. F. Mohler [see Abstract No. 108, (1900)]. That the pressure found by the latter should differ from their own result by as much as 45 per cent. they attribute to the different amounts of energy in the sparks under examination, which were produced by a transformer and a Ruhmkorff soil respectively. That the pressure is higher in illuminating gas than in air may be due to the fact that carbon was deposited from the gas upon the electrodes, and that the authors therefore really measured the pressure for carbon instead of brass. For carbon the observed spark pressure is indeed materially higher, and blackened electrodes give larger values than bright ones. The difference in the case of carbon dioxide may be accounted for by similar considerations. E. E. F.

2442. *Potential Gradient in Flame Gases.* **E. Marx.** (Ann. d. Physik, 2. 4. pp. 768–797, Aug., 1900.)—An apparatus is described which furnishes a gaseous pressure of about 0·1 atmosphere, constant to within 0·1 per cent. It is based upon the use of narrow capillary tubes. The pressure of the gas in the reservoir may alter considerably without sensibly affecting the velocity of efflux through the capillary tubes.

The potential gradient was measured between electrodes 17 mm. apart, the E.M.F. being furnished by 75 Clark cells. The temperature of the anode was varied by regulating the position of the flame. The object of the measurements was to find whether any acceleration of the positive ions could be attributed to a change of potential gradient produced by a reduction of the temperature of the anode. If the dissociation took place mainly within the volume of the flame, a change of the velocity ratio of the two kinds of ions would manifest itself in a change of the free charges. But such volume dissociation is only a part of the total dissociation, and the dividing line between the two kinds of dissociation cannot be definitely drawn. In any case, it is certain that the dissociation is not confined to the surface. E. E. F.

2443. *Dielectric Cohesion of Gases.* **E. Bouty.** (Comptes Rendus, 131. pp. 443–447, Aug. 20; 469–471, Aug. 27; and 503–505, Sept. 10, 1900.)—The value of the uniform field between condenser plates at which electricity first passes through the gas between the condenser plates measures the dielectric cohesion of the given gas at the given pressure. Assuming the field uniform at its centre, the critical potential gradient (volts/cms.) is y, which first decreases linearly with the pressure, passes through a minimum, and then increases indefinitely. Curves are discussed. Hydrogen is a worse insulator than air or CO_2 at high pressures, but a far better one at very low pressures. The critical fields here studied are analogous to those in which sparks pass, but are not identical, for here it is a question of currents, not of visible sparks. Where in hydrogen for currents the critical potential gradient $\gamma = 1{\cdot}4 + 63{\cdot}33\, p$, for sparks $y = 62 + 65{\cdot}09\, p$ (Wolf). The term proportional to the pressure is common to both: the first term depends on the work done at the surface bounding the gas, which work is not nil, even with vacuum discharges. Water vapour in itself and apart from deposited films of moisture, is a perfect insulator. As between different gases, the critical value of the potential gradient for the passage of currents presents an absolute term which is nearly the same for all, and a term proportional to the pressure the coefficient for which varies from gas to gas; but this coefficient does not seem clearly related either to the mean free path or to the specific inductive capacity. A. D.

2444. *Phosphorus Exhalations.* **C. Barus.** (Phys. Rev. 10. pp. 257–267, May–June, 1900. Paper presented to the Smithsonian Institute.)—By an electrical method (condenser leakage) it is ascertained that the rate of discharge of a freshly charged condenser, with air between the plates laden with phosphorus exhalations, is not discernibly different before and after an interval of nearly three hours; and the ionising potency of the phosphoric source does not appreciably diminish during comparatively short intervals, say fifteen minutes. But some kind of polarisation or counter current seems to be suggested by the falling off in saturation as we recede from the phosphorus. There appear definitely to be no obscure radiations accompanying the ionised particles exhaled by phosphorus, which are stopped by any mechanically impermeable medium and pass sometimes in very small, sometimes in larger proportion through porous papers. When they do pass the permeability dimimishes with lapse of time, as if deliquescing phosphoric acid clogged the pores. A. D.

2445. *Emission of Kathode Rays at Zero Potential.* **C. E. S. Phillips.** (Electrician, 45. pp. 773–774, Sept. 14, 1900. Abstract of a Paper read before the British Association.)—The green flecks produced upon the inner walls of vacuum bulbs by the action of kathode rays may be made to rotate by mounting the kathode upon a pivot and making it turn by some magnetic contrivance. It is found that the flecks persist even after either or both of the electrodes are connected to earth, and continue to rotate with the kathode. When a piece of metal is placed in a rarefied atmosphere, and made the negative pole for an electric discharge, innumerable small bright specks of light appear over the surface of the metal. The author used iron electrodes in order to be able to magnetise them, and to control the magnetic field. The latter made visible the lines of light emerging from the specks, and bent them in the well-known spiral manner. The number of jets becomes smaller as the exhaustion is continued, and finally the specks on the kathode disappear, while the green patches on the wall become brighter. The streams of gas lead to the deterioration of the vacuum. After the electrodes have been put to earth, the jets of gas continue to emerge, and are sufficiently ionised to produce green fluorescence. It is remarkable that fluorescence should continue to be produced when the velocity of the kathode particles has fallen below a limit which the author estimates as being the velocity of sound in air. E. E. F.

2446. *Mechanical Effects of Kathode Rays.* **H. Starke.** (Ann. d. Physik, 3. 1. pp. 101–107, Sept., 1900.)—Experimental determinations of the force exerted by kathode rays upon light movable bodies are as yet lacking, though Riecke has estimated the force acting upon a kathode shaped like a propeller. If the force thus found is regarded as that due to the reaction of projected particles, an amount of energy results which surpasses the whole energy of the kathode rays. It is, therefore, not permissible to deduce the kinetic energy of the kathode particles from such experiments. The author has adopted a different arrangement. He used a kathode with a number of plates resembling a propeller. But the kathode was kept fixed, and the kathode rays impinged at an angle of 45° upon a thin plate of aluminium suspended above the kathode by means of a thin platinum wire. The results were almost all negative. An influence machine gave nothing but irregular disturbances, probably due to electrical forces unconnected with the impact of kathode rays. An influence machine of 20 plates, yielding a discharge potential of 10,000 volts, and a current intensity of 10^{-7} amperes, gave something like an appreciable deflection, which indicated, however, that the force to be measured is below 10^{-4} dynes. The experiments are to be continued. E. E. F.

2447. *Reflection of Kathode Rays.* **H. Starke.** (Ann. d. Physik, 3. 1. pp. 75–100, Sept., 1900.)—Two years ago the author described a study of the diffused reflection of kathode rays, and showed that the reflected rays take their charges with them [see Abstract No. 87 (1899)]. He has since repeated the experiments with greater precautions, and has studied more especially the reflective powers of copper and aluminium for kathode rays. Mirrors made of the two metals were placed inside a metallic cylinder, through an opening in which the kathode rays entered. A galvanometer connected with the mirror measured the amount of kathode radiation absorbed. The amount reflected and diffused was measured by nearly surrounding the mirror with a second cylinder fitting in the first, and connected with another galvanometer. The two metallic cylinders were enclosed in a vacuum together with the kathode furnishing the rays. The mirror was put into two different positions in the cylinder, so as to determine the amount of kathode radiation diffused by the gas itself. The reflective power of aluminium was found to be 28·2, and that of copper 45·5, whatever the velocity of the kathode rays.

The author also devised a method of readily exchanging reflectors, and thus comparing the reflective powers of two metals without having recourse to absolute measurements. Taking the same value of 28·2 for aluminium as a basis, the reflective power of copper came out as 45·1. E. E. F.

2448. *Anode and Kathode during Discharge.* **K. Przibram.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 1161–1171, 1899.)—Comparison of discharges under varied conditions. The conclusion arrived at is that the discharge begins later at the positive pole and spreads out more rapidly than that at the negative. A. D.

2449. *Passage of Ions in Gases.* **J. S. Townsend.** (Nature, 62. pp. 340–341, Aug. 9, 1900.)—Negative ions which are produced in air by the action of Röntgen rays will produce other ions when they move through the gas with a velocity which is small compared with the velocity of light. The conductivity of the air is increased by the additional ions thus formed. A. D.

2450. *Projection of the Ether.* **P. de Heen.** (Phys. Zeitschr. 1. pp. 473–474, Aug. 4, 1900. From Archives de Genève, 9. and Bull. Acad. Roy. Belgique, 1899, p. 589.)—The author regards kathode rays as projections of the ether itself from the kathode. These projections carry material particles along with them, and can therefore exert mechanical force. When the rays impinge upon an anti-kathode, the material particles penetrate into the substance of the anti-kathode, and the rays, freed from their entanglement with matter, are better able to penetrate the walls of the tube and form Röntgen rays. The ether projections are brought into connection with the solar corona and the tails of comets. E. E. F.

2451. *Electromagnetic Waves and Diffraction.* **A. Lampa.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 786–802, 1899.)—Experimental and mathematical discussion of maxima and minima, with a total reflexion grating. The index of refraction of paraffin is found to be 1·44 for long waves. A. D.

2452. *Periodicity in Electric "Touch" of Chemical Elements.* **J. C. Bose.** (Roy. Soc., Proc. 66. pp. 450–451, Aug. 4, 1900.)—The phrase *electric touch* is here used in the restricted sense of sensitiveness to electric radiation, the touch being regarded *positive* when there is a diminution of resistance by the action of radiation, and *negative* when radiation produces an increase of resistance. A systematic inquiry into the action of nearly all the elements, including the metalloids and non-metals; also of some alloys, amalgams, and compounds, has led to the following hypotheses:—(1) That the contact sensitiveness depends on the chemical substance. (2) That the sensitiveness of an element is a periodic function of its atomic weight. (3) That the effect of radiation is to produce a molecular change or allotropic modification of the substance acted on, so that a positive substance becomes less positive, and a negative substance less negative. The change may in certain cases produce actual reversal. (4) That the so-called "fatigue" is due to the presence of radiation products. E. H. B.

2453. *Electric "Touch" and Molecular Changes produced by Electric Waves.* **J. C. Bose.** (Roy. Soc., Proc. 66. pp. 452–474, Aug. 4, 1900.)—This paper describes a number of experiments upon electric *touch* or contact-sensitiveness to electric radiation. From these the following conclusions are drawn:—(1) That ether waves produce molecular changes in matter. (2) That the molecular or allotropic changes are attended by changes of electric conductivity, and this explains the action of the so-called coherers. (3) That there are two classes of substances, positive and negative, which exhibit opposite variations of conductivity under the action of radiation. (4) That the production of a particular allotropic modification depends on the intensity and duration of incident electric radiation. (5) That the continuous action of radiation produces oscillatory changes in the molecular structure. (6) That these periodic changes are evidenced by the corresponding electric reversals. (7) That the "fatigue" is due to the presence of the "radiation product," or second allotropic modification. (8) That by means of mechanical disturbance or heat, this product can be transformed into the normal form, and the sensitiveness may thereby be restored. E. H. B.

2454. *Lecture Experiments illustrating Syntony.* **P. E. Shaw.** (Phil. Mag. 50. pp. 283–290, Sept., 1900. Paper read before the Physical Society of London.)—Following upon the work of Lodge [see Abstract No. 960 (1899)], the author devised experiments to illustrate in a lecture the use of syntony in magnetic space-telegraphy. The space over which it was desired to transmit the signals is here reduced to that of the lecture-room, but the receiver is required to make the result audible to an audience. The details of the problem were therefore quite different from those involved in signalling over greater distances to a single observer. The very considerable difficulties encountered were, however, finally overcome. The paper gives a summary of the theory involved, a full description of the sending and receiving circuits, and the precautions to be observed in manipulating the apparatus.

E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2455. *Resistance of Electrolytes in Motion.* **J. Nabl.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 1535–1558, 1899.)—This is an extension of the work of J. Bosi (Il Nuovo Cimento, ser. iv., tom. v.) on the change of resistance of electrolytes when moving rapidly either with or against the current. No change in resistance could be observed in the case of potassium hydroxide or hydrochloric and sulphuric acids when moving at 7 m. per minute with or against the current; and in entire contradiction to Bosi's results, no change could be detected in the case of zinc sulphate, copper sulphate, or potassium chlorate, either with a sensitive d'Arsonval galvanometer, or with a capillary electrometer as used by Bosi. The changes observed by Bosi differed in magnitude according to the direction of the stream, and are not therefore in agreement with any of the recognised theories of electrolysis, whereas the absence of any change, although a negative result, is in agreement with Hittorf's theory. The origin of the contradictory results of the two observers has not been ascertained. T. M. L.

2456. *Electrolytic Conduction in Vapours.* **A. Hagenbach.** (Phys. Zeitschr. 1. pp. 481–483, Aug. 4, 1900.)—To study the change of conductivity in vapours at the critical temperature, the author used solutions of sodium bromide or iodide in sulphurous acid. The resistance of the solution increased with the temperature, the increase being accelerated towards the critical temperature. But in all cases the conductivity had a small finite value at the critical temperature. On further heating the resistance increased, but more slowly. That was the course of events when the electrodes were immersed in the liquid. On inverting the tube, so that the electrodes were above the surface of the liquid, the resistance was infinite until close upon the critical temperature. At that temperature it reached a minimum, after which it rose again. The existence of a maximum conductivity at the critical temperature proves the existence of electrolytic conduction in vapours and gases. A further proof is afforded by the existence of a small though distinct polarisation. The electrical method is a valuable addition to the existing methods of studying the critical points. The critical temperature is always increased by the addition of a salt. In the author's experiments it ranged from 156° to 170°. E. E. F.

2457. *Electrocapillary Functions of Aqueous Solutions.* **Gouy.** (Comptes Rendus, 131. pp. 255–258, July 23, 1900.)—Discussion of curves of h (= height of mercury in a capillary electrometer) and Δ ($= L \mid Hg$, in volts at the meniscus), with different solutions and liquids L. The part of the curve where the slope is positive, and as far as a little way beyond the maximum, depends almost entirely upon the anion; the rest of the curve varies little, and depends chiefly on the kation. A. D.

REFERENCE.

2458. *Electromagnetic Theories.* **H. A. Lorentz.** (Phys. Zeitschr. 1. pp. 498–501, Aug. 11; and 514–519, Aug. 18, 1900. Address to the University of Leyden, Feb. 8, 1900.)—A review of the influence of electromagnetic theories, especially Clerk-Maxwell's, in directing research and in contributing to the progress of physical science, with reference, among others, to Hertz's work and to Zeeman's. G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2459. *Action of Chlorine on Metallic Silver in the Light and in the Dark.* **V. v. Cordier.** (Akad. Wiss. Wien, Sitzb. 109. IIb. pp. 540–555, June, 1900.) —The influence of light on the decomposition of silver compounds has been the subject of many investigations, but the formation of these compounds under similar conditions seems not to have received attention. A number of experiments on the action of chlorine on silver under different conditions of illumination are described in the paper; for details of the apparatus and methods employed the reader is referred to a previous communication (Monatshefte für Chemie xxi., 184–199, 1900). The following conclusions are arrived at:—Red light has no influence on the production of silver chloride, whilst blue and violet light favour the formation of the compound. Light which has filtered through a sufficiently thick layer of chlorine behaves like red light. The activity of white light is diminished much more by passage through moist, than through dry, chlorine. Admixture of small quantities of hydrogen with the moist chlorine still further diminishes the activity of light in promoting chemical action. The action of chlorine on silver is practically uninfluenced by Röntgen rays.

Similar experiments with bromine and silver are in progress. N. L.

2460. *Action of Sodium Hydroxide on Benzaldehyde.* **C. Pomeranz.** (Akad. Wiss. Wien, Sitzb. 109. IIb. pp. 288–300, March and April, 1900.)—The reaction between sodium hydroxide and benzaldehyde proceeds according to the equation—

$$2C_6H_5CHO + NaOH = C_6H_5COONa + C_6H_5.CH_2.OH,$$

and is hence a reaction of the third order. The author finds that the velocity constant of the reaction (calculated from the equation—

$$8Kt = 1/(a-x)^2 - 1/a^2,$$

a representing the initial quantity of sodium hydroxide and x the amount of it decomposed after the lapse of the time t) decreases as the reaction proceeds, this decrease being more marked in the case of concentrated solutions. By making use of the method proposed by Ostwald and van't Hoff for determining the order of complicated reactions, the concentration of the benzaldehyde being made very great compared with that of the sodium hydroxide, it is found that the concentration of the alkali enters into the differential velocity-equation in the second power, which would make the reaction one of the fourth order. The velocity constants calculated on this assumption are, when the reaction proceeds rapidly—with concentrated solutions and especially at the commencement—in much better agreement than the values for a reaction of the third order, but these latter hold better for dilute solutions. This apparent contradiction the author explains by supposing the reaction to occur in two distinct phases—

$$(1)\ 2C_6H_5.CHO + NaOH = (C_6H_5CHO)_2 NaOH$$
$$(2)\ (C_6H_5CHO)_2 NaOH = C_6H_5COONa + C_6H_5.CH_2.OH\ ;$$

the formation of such an addition compound is supported by the existence of similar bodies. The first of these two phases, which is of the third order, proceeds much more rapidly in concentrated than in dilute solutions, while the decomposition of the addition product will occupy a time which is independent of the concentration. Taking into account the fact that the addition product differs from sodium hydroxide and benzoate in not being ionised in solution, the author shows that in the case of concentrated solutions, the differential equation for the velocity of reaction is of the fourth degree. T. H. P.

2461. *Ultra-violet Absorption of Closed Chain Carbon Compounds.* **W. N. Hartley** and **J. J. Dobbie.** (Chem. Soc., Journ. 77. and 78. pp. 846–850, July, 1900.)—Measurements are given of the absorption spectra of 2:5-dimethylpyrazine, hexamethylene and tetrahydrobenzene in alcoholic solutions. The last two compounds show no selective absorption, thus confirming the conclusion that the banded spectrum is shown only by substances which possess the true benzenoid structure. T. H. P.

2462. *Partially Miscible Aqueous Inorganic Solutions.* **G. S. Newth.** (Chem. Soc., Journ. 77. and 78. pp. 775–778, July, 1900.)—On shaking concentrated ammonia solution with a saturated solution of potassium carbonate, the liquid separates into two layers, consisting of a saturated solution of the two solutions in one another. At ordinary temperatures, the potassium carbonate solution dissolves about 37 per cent. by volume of the ammonia solution, which in its turn takes up about 6 per cent. of the carbonate solution. These proportions increase with rise of temperature until the compositions of the two layers become identical, the liquids, at this critical temperature, being miscible in all proportions. The critical temperature is greatly influenced by the addition of small quantities of water, 6·9 per cent. of water added to the mixture sufficing to reduce it from 43° to 25°; similarly on dissolving anhydrous potassium carbonate in concentrated ammonia, the critical temperature of complete miscibility of the two layers is higher than when a saturated solution of the salt is employed. T. H. P.

2463. *Persulphuric Acids.* **T. M. Lowry** and **J. H. West.** (Chem. Soc., Journ. 77. and 78. pp. 950–961, July, 1900.)—Results are given of a study of the equilibrium of the system—sulphuric acid, water, persulphuric acid, hydrogen peroxide—the curve obtained being very similar to that corresponding with the equation—

$$C_1C_2 = 12{\cdot}6(C_3/C_4)^4,$$

where C_1, C_2, C_3, and C_4 represent the relative molecular proportions of the persulphuric acid, hydrogen peroxide, sulphuric acid, and water respectively. Assuming that the chief product of the interaction of sulphuric acid and hydrogen peroxide is a persulphuric acid of the series H_2O_2, *n* SO_3, it must be the fourth member having the formula H_2O_2, $4SO_3$. The deviations of the experimental curve from that deduced from the equation of the fourth order given above point to the formation of a small quantity of a lower acid of the same series, probably H_2O_2, $2SO_3$, which Berthelot assumed to be the sole product of the reaction. T. H. P.

2464. *Migration-Constant of Sulphuric Acid Mixtures from Measurements with Lead-Accumulators.* **A. Kendrick.** (Zeitschr. Elektrochem. 7. pp. 52–56, Aug. 2, 1900.)—Sulphuric acid concentration-cells with electrodes of Pb or

PbO_2 were measured. These measurements were combined with similar ones obtained with a concentration-cell (sulphuric acid) containing hydrogen-electrodes. Working in this way and employing very small concentration-differences, formulæ can be obtained which give the migration-constant of the H-ion in terms of the small E.M.F.'s measured, the other factors being eliminated, since the same concentrations were used both in the lead and hydrogen cells. The author gives tables showing how the values of the migration-constant so obtained vary with the concentration of the acid, and compares his results with those of previous workers in the same field. For numerical details reference must be made to the original paper. F. G. D.

2465. *Potential Fall and Dissociation in Flame-Gases.* **E. Marx.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 34–67, 1900.)—The departures from Ohm's law in flames under low E.M.F.'s are well known. Through the study of flame-conduction in a magnetic field we find that besides apparent departures due to saturation-current there is a true abnormality at low E.M.F.'s. The concentration of ions in a flame is a function of the temperature of the electrodes and falls as the temperature falls. If the temperature of the anode falls below a certain limit the positive ions undergo accelerations such that under approximately equal P.D.'s the curve of potential slope becomes approximately symmetrical and horizontal at its mid-course; and as the temperature falls still farther, the potential slope preponderates towards the anode instead of towards the kathode. With electrodes at the same temperature accelerations of the negative ions may present themselves at as low as 2 volts potential difference. The quantity of free positive electricity at the kathode falls off and the free negative charge at the anode increases as the anode cools down. The degree of flame-dissociation for the positive or for the negative ions depends upon the temperature of the corresponding electrodes. In a flame the points where unipolar conduction disappears are on isothermals. The slope of potential indicates by its variations the relative velocities of the ions. Arrhenius's observation that dissociation in a flame is electrolytic is apparently at variance with Coulomb's law, and appears explicable by attributing the electrolytic dissociation to the electromagnetic resonance of OH ions under ultra-red radiation, so that it is to be attributed to the somewhat accidental presence of these ions and their own proper electromagnetic note, not to any dissociating force in the flame. [See also Abstract No. 2442 (1900)]. A. D.

2466. *Difference of Potential between a Salt and its Non-Saturated Solution.* **A. Campetti.** (Accad. Lincei, Atti, 9. pp. 27–31, July 15, 1900.)—When a crystal of say NaCl is dropped into water or its own non-saturated solution, the chlorine ions fly off more rapidly than the sodium (63 : 38); the liquid immediately surrounding the crystal becomes negatively charged and the crystal is positively charged. This accelerates the outflow of Na and retards that of Cl ions, so that presently there is a tendency towards equalisation. On the whole the liquid is negative to the crystal. The difference of potential is of the same order as that between a more and a less concentrated solution of the same salt. A. D.

2467. *Electromotive Behaviour of Substances with Several Degrees of Oxidation, I.* **R. Luther** with **D. R. Wilson.** (Zeitschr. Phys. Chem. 34. pp. 488–494, Aug. 17, 1900.)—The conclusion that the oxidation of copper to the cupric state must represent an energy-change equal to the sum of those required to oxidise it to the cuprous and then to the cupric state is verified by measuring the E.M.F. of contact between copper and copper sulphate solution and comparing it with that of the combinations—

Cu | CuCl (solid) | KCl (solution)
and— Pt | CuCl (solid) | $CuSO_4KCl$ (solution),

as well as with similar combinations in which the bromides were used.

T. M. L.

2468. *Electrosynthesis of Organic Substances.* **O. Dony-Hénault.** (Zeitschr. Elektrochem. 7. pp. 57–65, Aug. 2, 1900.)—In a previous paper [Abstract No. 1715, (1900)], reactions were considered in which the discharge-potential of liberated ions was diminished by the presence of a non-electrolyte or depolariser with which the ions were capable of directly reacting. The synthesis of iodoform is now shown to belong to a different class of reactions, the discharge-potential of iodine ions in a solution containing sodium carbonate being unaltered by the addition of alcohol. The formation of iodoform, both by chemical and by electrolytic processes, is considered to be due, not to the direct action of iodine on alcohol, but to the secondary action of hypoiodous acid on alcohol. The hypoiodous acid is formed by the interaction of iodine and hydroxyl ions and partly undergoes decomposition with the production of iodic acid, partly reacts with the alcohol to form iodoform, the yield of the latter depending on the relative velocity of these two reactions. The correctness of the author's views is proved by the facts that (1) the conditions which are most favourable to the formation of iodoform by the electrolysis of a solution of sodium carbonate and potassium iodide in presence of alcohol are also those which are most favourable to the production of hypoiodous acid in the absence of alcohol; (2) the addition of excess of iodide or iodate, which hinders the decomposition of hypoiodous acid, favours the production of iodoform; (3) iodoform is readily obtained by the action of hypoiodous acid on a solution of sodium carbonate and potassium iodide in presence of alcohol, free iodine being entirely absent. N. L.

2469. *Electrolytic Conduction without Decomposition.* **Camichel** and **Swyngedauw.** (Comptes Rendus, 131. pp. 375–377, Aug. 6, 1900.)—The authors cause currents to flow in circuits composed entirely of electrolytes, with the object of seeing if any decomposition takes place. The necessary E.M.F. in the electrolytic circuit was obtained either by induction, a transformer being made with an electrolytic secondary, or by forming a closed electrolytic circuit in sections of different solutions, each contact giving rise to an E.M.F. No decomposition was observed. W. R. C.

2470. *Carbide of Calcium Works in Austria and Hungary.* **Gin.** (Ind. Électrochim. 4. pp. 71–76, July, 1900. Abstract of a paper read before the Paris Congress on Applied Chemistry, 1900.)—The hydraulic and electrical installations at six works are described in this paper—in some cases with great detail, in other cases only briefly. The works dealt with are situated at Meran, Paternion, Lend-Gastein, Mattrei, Jaice, and Lobkovice.

The Gin and Leleux type of carbide furnace is used at two of these works, namely, Meran and Paternion, and these are naturally the most fully described. The works at Meran have been frequently described [see Abstract No. 278, (1900)]. At Paternion a fall of 60 metres is utilised to drive three 400-H.P. turbines, each of which is direct coupled to a tri-phase generator. These generators run at 350 r.p.m. and generate current at 60 volts pressure. The furnace house contains nine furnaces of the Gin and Leleux double type, each equal to 125 E.H.P.

At Lend-Gastein a fall of 68 metres is utilised in turbines built by Escher-Wyss & Co., of Zurich. The total power generated is equal to 4,000–5,000 H.P., but no details of these works are available for publication.

At Matrei 1,500–2,000 H.P. is utilised. The turbines were built by Ganz & Co., of Buda-Pesth, and the generators and furnaces by Siemens & Helske.

The Jaice works have a maximum of 8,000 H.P. at command ; the eight turbines, each of 1,000 H.P., being by Ganz & Co. The generators and furnaces are by Schuckert & Cie. The early operation of this plant has been unfortunate, and important changes are now being made. At Lobkovice only 300–450 H.P. is available. Intermittent furnaces are used ; and 700–900 kg. carbide per day (300 tons per annum) are being produced here. J. B. C. K.

REFERENCES.

2471. *Theory of the Voltaic Cell.* **W. R. Cooper.** (Electrician, 44. pp. 434–436, Jan. 19 ; 45. pp. 852–854, Sept. 28 ; and 896–897, Oct. 5, 1900.)—Articles on the electrolytic mechanism and the osmotic pressure theory of primary cells.

2472. *Liquid Crystals.* **O. Lehmann.** (Ann. d. Physik, 2. 4. pp. 649–705, Aug., 1900.)—Paper similar to that referred to in Abstract No. 1876 (1900).

2473. *Theory of Solutions.* **G. Jaumann.** (Akad. Wiss. Wien, Sitzb. 109. IIa. pp. 512–553, May, 1900.)—A theory of solutions based on the Faraday-Maxwell theory, and independent of Arrhenius's theory of electrolytic dissociation, except in so far as two modifications of an electrolyte are postulated, of which one (in concentrated solutions) shows a normal osmotic pressure, and the other (in dilute solutions) a pressure twice as great. T. M. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2474. *Compound Steam Engine by the Prager Maschinbau A.-G. at the Paris Exhibition.* (Génie Civil, 37. pp. 181–183, July 14, 1900.)—This engine, which is to be used for lighting the station at Pilsen, has the peculiarity that the high-pressure engine has trip valves, and the low pressure cylindrical Corliss valves.

This arrangement was adopted in order to reduce to a minimum the steam consumption. Should any leakage occur with the H.P. trip valves the steam is not lost but goes to the L.P. cylinder. On the L.P., on the contrary, the clearances and chance of leakages must be reduced to a minimum, and this can be easily effected and maintained by the use of the Corliss valve.

The engine is a two-cylinder compound engine with the cranks set at 90° at either end of the crank shaft, and a Krizik dynamo in the centre. As the engine is running at Paris without condensing and at 120 revolutions, it indicates 240 H.P. The H.P. cylinder is 14·56 inches diameter, the L.P. 23·62 inches, with 27·56 inches stroke. The H.P. cylinder is surrounded by a jacket in which there is live steam; the L.P. jacket has the pressure of the receiver. The H.P. valve gear is a modified form of the Radovanovic gear. The lubrication is supplied from a main reservoir, and small cocks, situated near the parts to be lubricated, regulate the supply of the oil. The air pump, when fitted, is to be of the vertical double acting type and worked off the tail rod of the L.P. cylinder, through a bell crank lever. L. S. R.

2475. *Cylinder Proportions for Compound and Triple Expansion Engines.* **B. C. Ball.** (Engineer, 90. pp. 97–98, July 27, 1900. Paper read before the American Society of Mechanical Engineers, March, 1900.)—Opinion seems to be divided on the question as to whether there should be any terminal drop in any cylinder but the last, but no series of experiments of a conclusive nature seem to exist to determine this point. The author, after discussing the ideal diagram, cylinder ratio, &c., shows how these have to be modified in practice due to the varying conditions under which the engines may be called upon to work. The actual dimensions ultimately settled upon have in nearly all cases to be the result of a compromise. For instance, cylinder condensation modifies at once what would otherwise be the ideal dimensions and ratio of cylinders, &c. Greacen of Perth Amboy, New Jersey, made a lot of experiments by altering the initial pressure, and bushing the H.P. cylinder to alter the cylinder ratio, and the results of his experiments are given at some length, but are summed up in the following table :—

With 60 lbs. per sq. in. steam	Cylinder ratio 4 to 1
„ 85 „ „ „	„ „ 5 to 1
„ 110 „ „ „	„ „ 6 to 1
„ 135 „ „ „	„ „ 7 to 1
„ 160 „ „ „	„ „ 8 to 1

As a result of his investigations he gives the following as the main factors in the reduction of cylinder condensation :—

(1) Reduction to a minimum of the area under varying pressure and temperature. (2) Reduction of the range of temperature. (3) Use of steam jackets and reheaters or superheaters.

Rockwood has now built several compounds with a consumption of less than 13 lbs., and some have been as low as 12 lbs. per H.P. per hour. L. S. R.

2476. *Reheaters in Multiple-Cylinder Engines.* **R. H. Thurston.** (Mech. Engineer, 6. pp. 241–243, Aug. 18, 1900. Abstract of a paper read before the American Society of Mechanical Engineers at Cincinnati.)—Reheaters have been used since 1859, by various engine builders on both sides of the Atlantic. With the triple engine at the Massachusetts Institute of Technology, indicating 88 to 90 I.H.P., consumption of steam was 15·95 lbs. to 16·03 lbs., with no reheaters in use. With the reheaters in use, and the engine indicating 105–107 I.H.P., the consumption was 14·5 lbs. to 14·7 lbs. No jackets were used in either case. In the case of the Sibley College engine where jackets were used, no marked difference due to the use of reheaters could be detected.

Experience seems to indicate that 10 per cent. of superheat means about 20 per cent. saving in cylinder condensation. Reheaters in compound engines only affect the L.P. cylinder, and may probably reduce by one-half the cylinder condensation. The most striking successes in producing exceptional economy are exhibited by engines fitted with superheaters between the cylinders, thus securing a proper "reheat." A partial reheat in cylinders, when the ratio of expansion is small, is practically useless. The dimensions of the reheater must be proportional to the quantity of steam passing through, its degree of dryness and the quantity of superheat required, and where possible the actual moisture should be taken out of the steam before it reaches the reheater. A superheating reheater is a desirable accessory, but anything short of an actual superheat is undesirable, as this work, done by a complicated and costly apparatus, would be much better performed by an apparatus less costly in construction and maintenance. L. S. R.

AUTOMOBILISM.

2477. *Henriod Automobiles.* (Locomotion Automobile, 7. pp. 532–535, Aug. 16, 1900.)—A short biographical sketch of the work of Henriod in connection with motor vehicles is given, and a description of his latest type of 25-H.P. petrol car, with photographic and detail illustrations, showing clearly the main features of construction. The engine is placed at the extreme front of the underframe ; it has four horizontal cylinders arranged in pairs nearly opposite one another on either side of the crank case. The crank shaft lies in the direction of length of the vehicle, and drives through a friction clutch, a shaft in alignment, which runs in bearings in a gear case attached to the underframe. Upon this shaft are four fixed spur wheels, and upon a parallel shaft in the same horizontal plane is a sliding sleeve, carrying spur wheels so arranged that by shifting the position of the sleeve each may be caused to engage with the corresponding wheel keyed on the first shaft. Four forward speeds may thus be given to the vehicle, and a reverse motion may be obtained by engaging a third pinion between the pair of wheels which give the slowest forward speed, when these are out of engagement.

By means of a bevel gear the power is transmitted from the second motion shaft to a cross countershaft upon which is the differential gear. The road wheels are driven independently from this shaft by means of sprocket wheels and pitch chains.

Steering is controlled by a hand wheel which operates the pivoted axles of the front wheels through a worm gear and suitable links. Three band brakes are provided. The general design conforms to the accepted practice for high-speed carriages; the centre of gravity of the mechanism is low, and the engine well balanced. C. R. D'E.

2478. *Chaboche Steam Car.* (Locomotion Automobile, 7. pp. 594–596, Sept. 13, 1900.)—The author describes a steam delivery van for loads up to about 1 ton. The boiler is placed at the extreme front of the underframe and supplies steam to a pair of single cylinder horizontal engines placed on either side exterior to the frame members. The crank shafts are coupled, and the power is transmitted through a clutch and single reduction chain gear to the exterior of the differential which is mounted at the centre of the live rear axle. The special feature is the boiler, which is of the flash type, consisting of numerous coils of steel tubing arranged so that the connections are not exposed to the full heat of the furnace, and adapted to withstand very high pressures. Instead of the feed water being pumped direct through the coils, it is supplied under pressure of air at 200 to 400 lbs. per square inch, from a cylindrical vessel placed by the side of the driver. The air pressure is maintained by a pump driven by gear from one of the engines, and is controlled by a stop-cock within reach of the driver, as is also the feed of water to the boiler. The advantages claimed are that after a stop has been made the car may be started immediately instead of having to pump in water by hand as in other flash boilers; that when the car is stopped there is no pressure left in the boiler; and that the air pump has only to be worked intermittently to keep up the pressure above the feed water. The boiler is fired from the top; to facilitate stoking the fuel is done up in paper bags, each containing about 10 lbs. Particulars of cost of running, &c., supplied by the maker, accompany the article; also a photograph and a plan drawing of the vehicle. C. R. D'E.

2479. *Superheated Water Motor.* (Scientific American, 83. pp. 116–117, Aug. 25, 1900.)—A description of the system now being tried on the New York and Putnam Railway. Three carefully insulated storage tanks, having a total capacity of 700 gallons, are carried beneath the car, and are charged with water at a pressure of 700 lbs. per square inch at a temperature of 500°. Instead of taking steam directly from this, whereby the temperature of the whole would be rapidly diminished, a definite quantity of water is drawn off at each stroke from the bottom of the reservoir into a water-chamber at the end of the engine cylinder, and is thus not allowed to begin to evaporate until after it has finally left the reservoir. From this chamber a portion of the water is given off as steam, which is admitted to the cylinder in the usual way, the surplus water being drained off. Small compound engines are used, one pair on each truck, and drive the wheel axles through a pair of spur-wheels. It is expected that with tanks fully charged the car will be capable of running for forty miles at a speed of from thirty to forty miles per hour. [No details are given regarding efficiency.] H. R. C.

2480. *Road Locomotion.* **H. S. Hele-Shaw.** (Inst. Mech. Engin., Proc. 2. pp. 185–245 ; Discussion, pp. 246–253, April and June, 1900.)—This paper opens with a general statement of the circumstances which led up to the passing of "Locomotives on Highways Act of 1896, and consideration of the advantages consequent on the use of mechanically propelled vehicles for the distribution of goods in cases where the terminal charges make the cost of transport by rail prohibitive. Curves of cost of conveyance and terminal charges are given, which "show clearly that up to forty miles there is a field for a system of conveyance in the working of which terminals are not incurred." The "problem of the wheel rolling upon a road" is then considered, diagram illustrations being given of six types of wheels for heavy lorries of English construction; also graphical records, taken with Brown's viagraph, of the vibrations due to various road surfaces. The performance in practice of the several forms of wheel tyres is considered, and conclusions drawn therefrom, illustrations being given of four types of pneumatic tyre, and also of the "relative displacement caused by iron and pneumatic tyres at high speeds." "Steering and turning" forms the subject of the second part of the paper. With regard to the steering of motor vehicles, the author states that the great majority of these "are steered upon the principle invented by Ackermann as long ago as 1818." Diagram-illustrations are given showing the steering systems employed in the vehicles of Daimler, Clarkson and Capel, and others, and the Davis steering gear, the problem of obtaining differential movement of the steering wheels when describing curves being considered with reference to this latter diagram. "Turning," and the necessity of employing a "differential gearing, or jack in the box," are briefly considered. The third section of the paper deals with "Motive Power and Transmission," under which head the general considerations which govern the use of internal combustion engines, steam engines, and electric motors are dealt with. With regard to internal combustion engines, considerations are discussed in connection with carburettors, ignition, cooling, starting, governors, and balancing, diagrams of eight methods of balancing being given. Under the head of "External Combustion (Steam)" motors, diagrams are given illustrating the general distribution of the main parts of six English-built lorries. Several forms of liquid fuel-burners are then described and illustrated. The regulator employed in connection with the furnace of the Stanley boiler is referred to as a "burner" for the use of light petroleum spirit.

Steam generators are then dealt with, various types of water-tube and Flash boilers being illustrated and briefly described.

Electricity and transmission and gearing are considered, and finally the cost of transport by motor waggons, tables being given of the results of trials made at Liverpool.

Appendices are added which state the working cost of motor waggons in practice in four individual cases, and in a final appendix the results of the Automobile Club trials of 1899 are summarised by Bryan Donkin.

Discussion.—**J. A. F. Aspinall** stated that he had given one of Thornycroft's vehicles a trial in Liverpool and Manchester, and had found the results "fairly satisfactory for some kinds of work, but it could not be said that the vehicle was any cheaper than horse traction for all work." **J. Brown** described his "viagraph" and discussed its uses in the determination of the extra power required to draw a vehicle over rough roads. **Hele-Shaw** in replying said that the owner of a car in the 1,000-miles' trial then proceeding, stated that in estimating expenses he considered it about ½d. per mile for petroleum spirit, and about 2d. per mile for wear of pneumatic tyres.

[The discussion is continued in the following Abstract.] C. R. D'E.

2481. *Recent* 1,000-*miles' Road Trials.* **H. S. Hele-Shaw.** (Inst. Mech. Engin., Proc. 2. pp. 254–265 ; Discussion, pp. 266–321, April and June, 1900.)—This paper is supplementary to that dealt with in the preceding Abstract. It gives a short general account of the 1,000-miles' trial organised by the Automobile Club of Great Britain and Ireland, and is accompanied by a map of the route and tables giving particulars of the performance of the vehicles on the several hills included in the trial, and of the general running of the cars throughout. The author is of opinion that the general freedom from failure of many of the vehicles was due to the use of pneumatic tyres, and that the most important lesson of the trial was the absolute necessity for constant care and attention in order to obtain satisfactory running.

Discussion.—**Bryan Donkin** compared by means of curves the total running weight, and the cost of fuel per ton mile, as shown by the trials at Richmond in 1899, and at Birmingham in 1898. These curves show that "the cost of fuel is very much greater with the lighter and higher speed vehicles, and very much less with the heavier and slower vehicles." **H. Sturmey** mentioned that C. S. Rolls, who drove the largest and fastest pleasure cars in this country, had calculated the cost of pneumatic tyres at about 2d. per mile, and referred to the necessity for improvement in transmission gears rather than in the motors themselves. He said that three or four years ago he carried 15 gallons of cooling water on his petrol car, now only 4 gallons are carried owing to improvements in methods of cooling. **W. Worby Beaumont** spoke of the necessity for better roads, and criticised the author's remarks on the heating of carburettors for vaporising petroleum spirit, stating that the larger proportion of such carburettors required no heating at all. With regard to governors, engines were frequently run for part of the time at a normal speed of, say 750 r.p.m., but this could be accelerated to 1,500 or 1,600 r.p.m. by preventing the action of the governor. He also remarked on the inefficiency of certain methods of cooling the cylinders of petrol motors, and that the vibration in some motor cars was the result of infrequent ignition rather than of want of perfect balance of the moving parts. C. E. D'E.

GENERAL ELECTRICAL ENGINEERING.

2482. *Pasting Battery Plates.* **F. Peters.** (Centralblatt f. Accumulatoren u. Elementenk. 1. pp. 227–228, July 1; and 259–262, Aug. 1, 1900.)—Three methods of pasting plates for accumulators were tried—(*a*) That of S. Farbaky and S. Schenek (German Patent No. 87012), in which the material is mixed with 25 per cent. sulphuric acid; the mass when nearly dry is pressed into the grid, and is allowed to dry in the air for two to three days. It is next quickly dipped in 25 per cent. acid, drained, and after twenty-four hours again dipped in the acid, but this time sufficiently long to allow effervescence to take place. After standing a further twenty-four hours the plate is dipped for a third time for ten to twelve hours. (*b*) The process of J. Zacharias (Die Accumulatoren, Jena, 1892, p. 89), in which water only is mixed with the lead oxide, &c., and the paste pressed in the grids or formed into small rods. The plates are then dried and are ready for use. (*c*) That of W. L. Silvey (American Patent No. 459535), who mixes the oxide with water and applies the stiff paste to the plates, which, whilst the paste is still moist, are dipped into sulphuric acid of density 1·1–1·2, where they remain, according to the thickness of the plate, for two to three days. The process is then complete, and they may, if necessary, be so far dried that they can be handled without damage. Cells were built up with these three types of plates, and tested by discharging at various rates. Observations were also made with the use of a supplementary cadmium electrode. [See Abstracts Nos. 1068 and 1416 (1899)]. The following table is given :—

Rate of Discharge Amperes.	Watt-hour Capacity.		
	Farbaky-Schenek.	Zacharias.	Silvey.
4·2	34·27	25·59	26·27
6·0	28·52	22·68	22·80
8·4	26·33	18·46	18·51
10·0	21·63	18·51	13·75
14·0	21·14	19·32	19·31

W. W. H. G.

2483. *Battery Plates for Traction.* **J. K. Pumpelly.** (Elektrochem. Zeitschr. 7. pp. 83–86, July, 1900.)—Three photographs are given of accumulator plates that had been used about two months in an electric car. The type of plate which had most suffered was of the Planté type. It had been produced electrochemically in a solution of sulphuric and nitric acids. Mechanically it represented a new process, and was carefully manufactured. This compared very unfavourably with a Faure plate from the same car, and which had done the same amount of work. W. W. H. G.

2484. *Burning of Accumulator Plates.* **O. Schmidt.** (Centralblatt f. Accumulatoren u. Elementenk. 1. pp. 216–218, June 15, 1900.)—The author advocates the use of oxygen and hydrogen produced by electrolysis. The method presents so many advantages that it has been adopted in most of the works in which Tudor accumulators are manufactured. The gases are produced in a filter-press type of decomposition apparatus, in which the separate chambers are in series so that the apparatus may be directly connected with the main electric leads. The construction of the apparatus (of which no details are given) prevents the admixture of the gases. The gases are especially pure, the hydrogen being 99 per cent., and the oxygen 97 per cent. From the decomposition apparatus the gases may be led directly to the blowpipe. If small gasometers be used the required small differences of pressure may be maintained. The apparatus may be continually worked with but little attention. The blowpipe requires each hour 100 litres of hydrogen and 33 litres of oxygen. W. W. H. G.

2485. *Dry Accumulators.* **C. Liebenow.** (Centralblatt f. Accumulatoren u. Elementenk. 1. pp. 67–70, Feb. 15, 1900.)—In Germany a number of patents exist for storage cells in which the electrolyte is held by absorbent materials [see Zierfuss D.R.P. No. 95269, Behrend No. 103044, Chemische Fabrik Winkel No. 109016]. Among the materials used have been glass, wool, porous siliceous earth (*Kieselguhr*), albumen, starch-paste, baked clay, pumice-stone, cellulose, soap, fatty acids, gypsum, sand, asbestos, and patent gelatine. The disadvantages arising from the use of these materials is pointed out, and the many troubles that are likely to arise are enumerated. Hitherto experiments in this direction cannot be regarded as very successful. W. W. H. G.

2486. *Controllers for Continuous Current Electric Lifting Gear.* **M. Vogelsang.** (Elektrotechn. Zeitschr. 21. pp. 635–640, Aug. 2, 1900.)—In this paper the author first deduces equations for the distance x through which the load Q will move after the current has been cut off. In the case where the load is being raised—

$$x = \frac{\eta \cdot \dfrac{m_2 v^2}{2} + \dfrac{m_1 c^2}{2}}{Q + \eta B}$$

where η is the efficiency of the gearing when kinetic energy is being converted into potential energy, m_1 the mass of the load, m_2 the reduced mass of the armature and v the velocity thereof, c the velocity of the load, and B the braking force. For the case, where the load is falling—

$$x = \frac{\dfrac{m_2 v^2}{2} + \eta' \dfrac{m_1 c^2}{2}}{B - \eta' Q}$$

where η' is the efficiency of the gearing when potential energy is being converted into kinetic energy. In practice η lies between 0·5 and 1 and η' is positive, B must therefore be at least equal to $\eta' Q$ in order to be effective.

The system of control employed by the author consists in short-circuiting the motor through more or less resistance, so as to regulate the braking force, and thus the velocity at which the load descends. A mechanical brake is thus only required for bringing the load to a standstill. This brake can be kept normally in the "on" position by means of a spring or weight, and be released by an electromagnet, which is wound for connection in parallel with the motor, and is itself provided with a high-resistance shunt to receive the induction current when the circuit is broken. This shunt is preferably permanently connected across the terminals of the electromagnet; it may, however, only be thrown into circuit, when required, by means of the controller. The controller whereby the above-mentioned connections are made consists of a vertical shaft bearing insulated segmental contact-pieces engaging with spring contact-fingers, spaces being arranged between adjacent fingers, and into these spaces extend the pole-pieces of electromagnets, so as to prevent arcing. Diagrams are given showing various schemes of connections, together with photographs of several forms of controller, and a section of one of them. C. K. F.

2487. *Insulation by Freezing.* (Elect. World and Engineer, 36. p. 287, Aug. 25, 1900.)—The dielectric strength of ice increases with a falling temperature, and is more particularly effective against intermittent currents or those alternating at high rates. Tesla suggests inserting a transformer in a freezing jar, and has patented a system of underground conductors where the two mains are the flow and return pipes which carry a cooling material, the pipes themselves being buried in wet cement or water, &c., in a trough. M. O'G.

2488. *Power Transmission by Shafting* versus *Electricity.* (Eng. News, 44, pp. 18–21, July 12, 1900. Abstract of a report presented by a Committee at the Convention of the American Railway Master Mechanics' Association.)—The average efficiency from engine to tools for steam engine transmission is 50 per cent.; from motor to tools it is 52 per cent. where the machines are grouped on shafting, or 60 per cent. where each tool has its own motor. Where electricity is substituted for steam, the attendance bill will be practically unaffected in a large shop, as also will be the repairs bill. The capital cost of electric equipment will be approximately double that of steam equipment, but the former has enormous advantages, because it permits labour-saving devices, cranes, &c. In ordinary steam-equipped factories the tools have generally to be installed with a view to convenient application of power; with electric equipment, the tools are placed where the work can be handled with most advantage. Increased output is the chief advantage in motors.

A valuable table is given showing the power required for various machine tools. With electric plant, the efficiencies at full load are: Generators 86 to 90 per cent., transmission lines 90 to 95 per cent., motors 78 to 90 per cent.; overall 62 to 77 per cent. At partial load the machine efficiencies drop, but the line efficiency rises so that the overall efficiency is practically independent of the load. In an average size railway shop plant, the all-day efficiency from engine to motor pulley may be taken as 65 per cent. As a rough guide in planning shop power plants, it may be noted that each man in a railway shop will require roughly 0·4 H.P.

The disadvantage of the alternating current motor for general shop work is its high and not easily-varied speed. For shafting this is quite satisfactory. The induction type alone is applicable for shop uses.

For generators of 75 H.P. or less, belt-driving answers all practical purposes, but above this size direct-coupled sets are more economical. The generator load in a shop seldom exceeds 50 per cent. of the combined motor capacities, and the effect on the generator of running travelling cranes, turn-tables, &c., need not be considered. For individual tool-driving the compound-wound variable-speed motor is recommended as a substitute for the usual shunt-wound motor. One of the chief advantages of electric driving is the possibility of simple speed regulation for large tools. For travelling cranes, hoists, transfer tables, turn-tables, and boiler-shop plate rolls, which start under load, run at variable speed, stop and reverse, the series-wound motor is the best. In general, where tools require less than 3 H.P. each, it is best to group them on short line shafts in groups not exceeding 25-H.P. Where more than 3 H.P. is required or where variable speed or intermittent running is desirable, each tool should have its own motor. The conclusions arrived at are that (i) in a small shop consisting of one building equipped with small tools for light work, electric driving is not a paying investment, but electric lighting is economical, and the lighting dynamo may be utilised to run a few labour-saving electric tools, such as cylinder borers, turn-tables, &c.; (ii) in an extensive railway shop plant, a central power station and electric transmission are always advisable, as they result not only in the most economical system of operation but make possible more important shop economics, viz., an increase in quantity and quality of output and a reduction in cost of handling the same.

In an appendix, examples of shop power plants are given, including descriptions of those at the Westinghouse Air-Brake Company's works and the Baldwin Locomotive Works. The former company replaced 23 scattered Westinghouse steam engines of 5 to 200 H.P., driving line shafting, by three 400-H.P. Parson's steam turbines in a power house close to the boilers. The turbines are direct-coupled to three-phase alternators, running at 3,600 r.p.m., which supply 56 induction motors having an aggregate capacity of 1,050 H.P. The original shaft sections were about 400 feet long, and belted to their engines in the centre. These sections have now been cut into four parts, and a 15-H.P. motor belted to each 100 feet. Thorough comparative tests were made with the old steam and new electric driving, and the results show a saving for the latter, during a day's run of 11½ hours, of 33 per cent. of fuel consumed and 40 per cent. of water evaporated. E. H. C.-H.

REFERENCES.

2489. *Alternate Current Meters.* **H. Armagnat.** (Écl. Électr. 24. pp. 92–97, July 21, 1900.)—An article, illustrated by patent drawings, describing the Hookham, Thomson-Houston, Davis and Conrad, and the Siemens meters.

2490. *Electrical Coal Cutters.* **S. F. Walker.** (Eng. Mag. 19. pp. 712–727, Aug. 1900.)—An illustrated article descriptive of various types of electrical coal cutters.

2491. *Heating of Underground Cables.* **K. Wilkens.** (Elektrotechn. Zeitschr. 21. pp. 691–692, Aug. 9, 1900.)—The author here criticises a paper on the same subject by Apt. [Elektrotechn. Zeitschr. 26. July, 1900, and Abstract No. 1925 (1900)], and attacks the assumptions made in the theoretical portion of the paper dealing with the conduction of heat from the cable. J. B. H.

2492. *Design of Tractive Electromagnets.* **W. E. Goldsborough.** (Elect. World and Engineer, 36. pp. 125–132, July 28, 1900.)

GENERATORS, MOTORS, AND TRANSFORMERS.

2493. *Determining Moments of Inertia of the Rotors of Dynamos.* **A. Hay.** (Elect. Rev. 47. pp. 287–288, Aug. 24, and 327–330, Aug. 31, 1900.)—A clear description is given of five methods of experimentally determining the moments of inertia of the rotors of dynamos. In problems connected with the parallel running of alternators and in analysing the various losses which take place in a generator a knowledge of these moments of inertia is essential. The first method described is the ordinary laboratory method of determining moments of inertia by means of torsional vibrations. The rotor is suspended by a steel wire rope, and the time of a complete oscillation (T_1) is observed. Its moment of inertia is next increased by distributing weights symmetrically round the axis. Let T_2 be the new period and let I be the moment of inertia of the rotor, and I_w the added moment of inertia, then—

$$I = I_w \frac{T_1^2}{T_2^2 - T_1^2}.$$

Results of experiments are given showing that this is an accurate method in practice.

In the second method the machine is run up to any desired speed, and then the power being cut off, the angular velocities (ω) of the rotor are noted at subseqent intervals. From these readings a curve is plotted. From this curve the rate of decrease of the angular velocity ($d\omega/dt$) for any particular value of ω can be found by drawing a tangent to the curve in the ordinary way. If the value of the retarding torque be T, then $T = -I\, d\omega/dt$. If we now mount a disc flywheel on the rotor shaft and obtain a new retardation curve, then—

$$I = I' \frac{d\omega_2/dt}{d\omega_1/dt - d\omega_2/dt},$$

where I' is the moment of inertia of the disc flywheel, and $d\omega_1/dt$ and $d\omega_2/dt$ denote the angular accelerations corresponding to the same value of ω in the two cases.

In the third method the machine is run as a separately-excited motor, and the torque is calculated from the watts (W) given to the armature. Hence we can find I from the equation—

$$I\omega\, d\omega/dt = -10^7(W - C^2R)$$

where C^2R is the power expended in heating the armature. The readings on a Weston voltmeter connected across the brushes were used to find the speed as the rotor slowed down. It was found that the friction varied very irregularly for the first half-hour or so. In order to get satisfactory readings the rotor had to be kept running for two or three hours. In the fourth method two retardation curves were obtained, one being the normal curve and the other corresponding to a larger resisting torque caused by putting a suitable resistance across the machine terminals. The additional torque (T_0) is calculated from the current, the resistance of the circuit, and the angular velocity. Then—

$$I = \frac{T_0}{d\omega_1/dt - d\omega_2/dt}.$$

The fifth method only differs from the fourth in increasing the torque mechanically instead of electrically. An accurate method of getting the retardation curve is by a smoked recording drum similar to those used in physiological laboratories. Diagrams made by one of those instruments are shown. A. R.

2494. *Locating Short-circuits in Armatures.* (Street Rly. Journ. 16. pp. 583–585, Aug., 1900.)—The North Jersey Street Railway Company locate short-circuits in their armatures by the alternating-current method. The armature is mounted on the winding bench or lathe, and a portable testing-stand brought up to it. This stand consists of a framework of angle-iron mounted on rollers and carrying a magnetising spool on a curved pole-piece shaped to fit against the outside of the armature. The magnet core is made of laminated iron about $\frac{1}{32}$ in. thick, and its shaped face is about 11 inches long by 11 inches high. The magnetising coil is wound with 1,210 turns of No. 68 B. & S. wire on a spool $11\frac{5}{8}$ in. × $3\frac{5}{8}$ in. × $3\frac{3}{8}$ in. The curved face of the polepiece is adjusted to the face of the armature by a hand-wheel and screw. The armature is rotated by hand in this alternating field, and a thin strip of iron is passed around the armature. When this strip comes over the tooth lying between two short-circuited coils it will vibrate in unison with the alternating current supplied to the magnet. This vibration is due to the fact that the magnetism produced by the local flow of induced current in the short-circuited coils is not synchronous with the magnetism in the adjacent teeth. When placed at any winding bench an armature can be tested by this method in less than one minute. E. H. C.-H.

2495. *Parallel Operation of Direct-connected Alternators.* **H. G. Stott.** (Elect. World and Engineer, 35. pp. 240–241 and 255–256, Feb. 17, 1900.)—Owing to armature reaction it is necessary that the voltage of the incoming alternator should be somewhat greater than the voltage at the bus-bars. The armature reaction is specially marked at low-field excitation. The running machine has already had its field adjusted to compensate for its armature reaction, and when the incoming machine is thrown in parallel with it a slight difference of phase is sufficient to allow the running machine to send an almost wattless current into it, tending to demagnetise its fields and finally drive it as a motor. W. G. R.

2496. *Single-phase Induction Motors.* **C. P. Steinmetz.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 37–78, Jan.; Discussion, pp. 170–180, March, 1900.)—The principal feature of this paper is a description of the use of a condenser connected to a tertiary circuit in a single-phase motor. The tertiary coil is wound at right angles to the stator winding, so that the mutual induction between the two is approximately zero. The E.M.F. developed in the tertiary winding is therefore due to its mutual induction with the rotor coils. The result is that an E.M.F. is induced in the tertiary coil which is suitable for a condenser connected in series with it. If this condenser has the same admittance as the rotor exciting admittance the tertiary circuit gives the secondary magnetising current, that is, the secondary current becomes zero at synchronism, just as in a polyphase motor, and the primary current is reduced to the magnetising current of the main magnetic flux only. If twice this capacity is used the condenser current in the tertiary circuit supplies the magnetisation of the quadrature magnetic flux, and at the same time causes a current in the secondary to flow which gives the primary magnetisation also, and the primary circuit carries energy current only, that is, the total magnetisation is given by the condenser in the tertiary circuit, or the motor has 100 per cent. power factor. W. G. R.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2497. *Regulation in Long-distance Transmission.* **C. L. Cory.** (Journal of Electricity, S. F. 10. pp. 6–9; Discussion, pp. 9–13, July, 1900. Paper read before the Tamalpais Meeting of the Transmission Association, June, 1900.)—The author considers the question of regulation in the case of the transmission line now being installed by the Standard Electric Company of California. This line, 150 miles in length, is to transmit 10,000 kw. from the Mokelumne River to San Francisco, at a pressure of 60,000 volts. The system is three-phase and the line consists of three aluminium stranded wires, ¾ inch in diameter, having cross sections of 471,034 circular mils. The resistance per mile of the wire is 0·205 ohm at 70° F. The distance between the conductors is 42 inches. The frequency to be adopted is 60. The author makes his calculations for a single-phase transmission delivering 3,000 kw. The inductance of the line is 0·48 henry. The impedance at 60 ∿ is 200 ohms, at 30 ∿ 113 ohms. The capacity of the line (neglecting the influence of the earth) is 1·43 m.f., and the charging current due to this at 60,000 volts is 32·25 amperes at 60 ∿. The apparent energy required to charge the open line is 3,348 kw., and the real energy 32 kw. Assuming the capacity to be distributed, one-sixth at each end and two-thirds in the middle, a voltage of 47,676 volts at the generator would produce 50,000 volts at the distant end, on an open line. Taking a full-load current of 60 amperes with a power factor of unity to deliver 60 amperes at 50,000 volts, there must be supplied by the generator 67 amperes at 58,800 volts; the watt loss is 10 per cent. With a power factor = 0·8, the inductive current is 45 amperes, and the charging current 32 amperes, and these tend to neutralise each other; the current required at the distant end to give 3,000 kw. at 50,000 volts is 75 amperes, and the generator must supply 62·1 amperes at 60,000 volts.

The author concludes by pointing out that the best way to reduce the charging current is to produce a neutralising inductive current by the use of induction motors at various points throughout the length of the line; induction motors are preferable in this respect to artificial impedance coils.

Discussion.—**Lighthipe** stated that in Southern California three-phase plant at 33,000 volts, the capacity of the line was considerably diminished by earthing the centre of the star at each end of the line. **Cory** (in reply to various questions) stated that the capacity of the line varied materially with the atmospheric conditions. Synchronous motors had the opposite effect to induction motors unless they were run with weak fields, which was not their best working condition. G. H. B.

2498. *Regulation in Long-distance Transmission.* **F. A. C. Perrine.** (Elect. Rev. N.Y. 37. pp. 152–153, Aug. 15, 1900. Paper read before the Pacific Coast Electric Transmission Association, June 19, 1900.)—The author treats of electric transmission of power, obtained from high heads of water, for long distances at high pressure. For the regulation he makes the following recommendations:—Water-wheels should be subdivided into sets of small units driving one generator, and their regulation effected by deflecting nozzles; the objections to regulation by varying the flow of water is that with high velocities of the water, this causes a variation in the level of the water in the forebay, and so affects the other wheels. Small units are advisable to save water by shutting down one or more as the load decreases. Generators and transformers should be designed, not for good non-inductive, but for good inductive, load regulation. Lines should be designed for the smallest possible capacity-current without reference to any attempt at balancing the line capacity against the load lag; such balancing is useless because the capacity current remains practically constant, while the inductive drop varies with the load. At the substations, reactance coils should be used to regulate the voltage instead of regulator transformers; reactance coils neutralise the capacity current and diminish the generator current and line loss at no load. G. H. B.

2499. *Copper Saving in the Joint Transmission of Direct and Alternating Currents.* **F. Bedell.** (Elect. World and Engineer, 35. pp. 984–985, June 30, 1900. Abstract of paper read before the American Association for the Advancement of Science. Also Elect. Rev. 47. pp. 32–34, July 6, 1900.)—The author points out that if two direct currents or two alternating currents of the same phase and frequency, i_1 and i_2, are transmitted along the same conductor the joint heating effect is given by $R(i_1 + i_2)^2$, where R is the ohmic resistance of the conductor. If, however, a direct current i_1 and an alternating current i_2 are simultaneously transmitted along the same conductor the heating effect is only $Ri_1^2 + Ri_2^2$ since they behave independently. Thus the loss with a direct current and an alternating current superimposed is less than two direct currents of the same virtual values by the quantity $2Ri_1 i_2$. W. G. R.

2500. *Electric Transmission of Power in Factories.* **W. S. Aldrich.** (Mech. Eng. 5. pp. 822–825, June 9, and pp. 849–851, June 16, 1900. Paper read before the American Society of Mechanical Engineers, May, 1900.)—For all manufacturing operations (except the very lightest) requiring rotary motion, electric motors provide the readiest facilities. For certain very definite reciprocating movements with fixed time or distance limits, hydraulic mechanisms are best suited, though electrically driven hydraulic mechanisms with hydraulic control have proved admirably adapted to this class of work. For reciprocating movements requiring a cushioning effect, compressed air is best adapted. But for efficient service in any case compressed air requires to be reheated and used expansively in a cylinder with all parts and mechanisms practically the same as in the steam engine. An important advantage of electric driving is the comparatively high efficiency at part load. The best performance of the electric system of transmission by shafting and belts is at full load. The best performance of the electric system may be maintained from three-quarter load to 25 per cent. overload.

In the second article the author remarks that the induction motor is the most perfect motor yet developed for electric transmission in factories. It can be started from any point at almost any load and speed within its predetermined ranges. It requires no direct current for excitation, no brushes, commutator or collector rings. Its speed, however, falls off slightly as the load increases and the ability to start an induction motor from rest under a heavy load, as well as the possibility of speed changes during its operation, are obtained at some sacrifice of efficiency. It can be run at higher lineal speeds (7,000 feet per minute) than any other type. With suitable arrangements of field windings, its speed can readily be altered

in regular steps corresponding to the steps of change-wheels. If overloaded the induction motor does not readily burn out but tends to stop until the load is lightened. On account of power factors, a larger generating plant is required for an installation of induction motors than for one of direct-current motors. Synchronous motors are best where absolute uniformity of speed is required. Their power factor can be almost anything from zero to unity according to the amount of the direct-current excitation. In the revolving field type, synchronous motors are self-starting from rest at light loads, and can be designed to carry at least three times their full normal load without falling out of step, but will then be inefficient at ordinary loads. Synchronous motors have higher efficiencies than induction motors and both are generally superior in this respect to direct-current motors. The ideal conditions in a factory installation would be secured where both induction and synchronous motors were used, the former for small machines and direct driving, the latter for operating a set or group of machines. The synchronous motors would be started up just before beginning the work of the day, would have at all times a light constant load, and might easily be so regulated as to produce an almost balanced system in combination with the induction motors. In such a system of transmission, the lagging currents of the induction motors would be offset by the leading currents of the synchronous motors, if the latter were operated to produce such leading currents.
E. H. C.-H.

2501. *On Earthing Certain Portions of Distributing Systems.* **C. H. Wordingham.** (Elect. Engin. 26. pp. 93–95 ; Discussion, pp. 95–96, July 20, 1900. Paper read before the Municipal Electrical Association.)—If all parts of a two-wire 10,000-volt system be equally well insulated, then each wire will only differ by 5,000 volts from the potential of the earth. If, however, one conductor's insulation diminishes, the potential of the other conductor with regard to earth will at once increase. Ferranti first pointed out that, as either conductor may therefore have to withstand the full pressure it would be better to insulate one of them for the maximum pressure and ensure that it alone shall be subjected to this pressure by connecting the other conductor to earth. This simple device at once diminished the risk of breakdown, cheapened the cost of insulation, and admitted greater security to life by enclosing the insulated conductor within the uninsulated one, thus rendering it physically impossible to handle a conductor at a dangerously high potential. It is important that one point only of the zero potential conductor should be connected to earth because there is necessarily a fall of potential down its length, and, if two distant points are earthed, current will tend to pass from one to the other through the earth, and these return paths may be at almost incredible distances from the main conductor.

In the case of low-pressure distribution, the object of earthing one conductor is not to diminish the cost of insulation because there is no appreciable difference in the cost for 200 volts and 400 volts ; nor is it to secure safety to life : the chief object is to enable a consumer to be supplied at such a pressure that no one of the conductors brought into his house will exceed the limit of pressure defined by the Board of Trade to be low pressure. For keeping down the drop on the earth return of tramways, the author considers it best to feed the line from a number of independent points, either by separate generating stations or preferably by a number of transforming substations.

In a three-wire system the advantages of earthing the middle wire are chiefly those referred to above. The disadvantages are :—(i) If a leak exists on one conductor, current is continually forced through it, thus often causing complete destruction of the insulating material : (ii) A leak on one conductor produces a short-circuit on one side of the system unless the earth connection is removable at will. In Manchester the Board of Trade requires the negative conductor of the three-wire system to be maintained at or near earth potential. In the author's opinion this undoubtedly has very severe results on the negative main with continuous currents and probably with alternating also. This effect is due to electric osmosis, whereby moisture tends to travel away from the positive pole towards the negative pole. The author finds that this occurs not only at the surface of the insulation at points of connection, but, with certain makes of rubber, at any points in the length of the cable, the rubber being evidently porous ; and though the leakage current is small at first, it suffices to cause water to enter through the pores of the rubber, thereby increasing the conductivity of the leak and eventually destroying the whole of the rubber on the negative conductors. Large blisters form within the rubber and become filled with strongly alkaline liquid, which is often under considerable pressure from the distended rubber, this pressure gradually increasing till it bursts the rubber and makes a hole completely through the insulating material. It is clear that the water cannot simply flow into the originally minute pores : it is driven in by osmosis. What happens with rubber may happen with other materials.

The author considers that the only method of effectually balancing a three-wire system is to carry the balancing back to every consumer except the smallest, and he considers that the advantage of being able to do this outweighs the disadvantages of earthing the middle wire. The utmost care, however, must then be taken to protect the mains from moisture and the only possible systems of laying mains are the " solid " system and the air-insulated systems with accessible porcelain insulators. The earth connection should be removable, continuity of supply being the first consideration ; it then becomes essential that the conductors should be earthed at one point only, which makes the use of an uninsulated return in a consumer's installation impossible. With such an uninsulated system, local earth currents between neighbouring installations would be unavoidable.

Discussion (pp. 95–96).—**A. P. Trotter** suggested inserting a resistance of 1 ohm in the earth connection to prevent a dead short-circuit. The advisability of keeping the lead sheathing 2 or 4 volts negative to the middle bus-bar is worth consideration. **R. Chamen** found it advisable to earth the middle wire through a resistance, owing to the importance of not overheating a concentric cable by a short-circuit. He ascertains the existence or absence of earths on the system by interposing an E.M.F. between the earth wire and its return, and noting the alteration in the earth current.

E. H. C.-H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2502. *Rathmines Electricity Works.* (Electrician, 45. pp. 631–632, Aug. 17, 1900.)—*System :* Continuous-current, three-wire, with 200 volts on each circuit, and batteries.

The *boiler-house* contains three Lancashire boilers by Taylor & Sons, each 30 feet by 8 feet, and capable of developing 7,000 lbs. of steam per hour at 160 lbs. per square inch. They are fitted with Vicars' stokers. The feed-water is heated by a 96-tube Green economiser, and is supplied either by an injector, or a steam-driven pump, or a pump driven by a Lundell motor. A 6-H.P. Crompton motor drives the stokers and the economiser scrapers.

The *engine-room* contains one three-crank triple-expansion engine indicating 575 H.P. at 320 r.p.m., with cylinders 720 mm., 480 mm., and 320 mm., and stroke 260 mm., and one two-crank compound engine indicating 240 H.P. at 360 r.p.m., with cylinders 600 mm. and 360 mm., and 200 mm. stroke. Each engine has a combination bed-plate, taking for the larger one, two 150-kw. 220-volt dynamos, and for the smaller, two 75-kw. dynamos, by Mather and Platt. A 30-inch jet condenser, by the Wheeler Condenser and Engineering Company, is employed, working with the same firm's horizontal wet and dry vacuum pumps, and a cooling tower 60 feet high.

The battery consists of 274 Tudor cells, of which 50 on each side are for regulating. Their capacity is 800 ampere-hours for 10 hours or 650 for 8½ hours, and their maximum discharge is 216 amperes.

The mains are triple-concentric, lead-covered, laid in cast-iron troughs filled with bitumen. The network is fed at seven points by 0·4 square inch and 0·3 square inch feeders, each with a pilot wire. The distributing network consists of 0·1 square inch and 0·05 square inch cables, of which about 16 miles are laid.

For street lighting 108 10-ampere Crompton arcs are run in twelve circuits of nine each, each arc having a turn-over switch and automatic cut-out with substitutional resistance; there are also 550 16-c.p. incandescent lamps on poles carrying two lamps each. G. H. B.

2503. *Stockport Electricity Works.* (Elect. Rev. 47. pp. 263–265, Aug. 17, 1900.)—*System:* Continuous-current, three-wire, with batteries; 230 volts on each circuit.

The *boiler-house* contains two Lancashire boilers 28 feet by 8 feet, by Tetlow Brothers, fitted with Wilton furnaces for burning coke breeze, the refuse of the gasworks; three cast-iron tubes, acting as fire-bars, are fitted with steam jets, which force an air-blast into the fuel through numerous small holes in the tubes. The boiler pressure is 200 lbs. per square inch. The feed-water is heated by a Berryman heater and is fed by two Worthington pumps.

The *engine-room* contains five Willans two-crank triple expansion engines, three of 56 kw. and two of 140 kw. Each drives directly a two-pole McClure and Whitfield dynamo. The smaller give 224 amperes at 220–310 volts and 450 r.p.m., and the larger give 280 amperes at 460–500 volts and 350 r.p.m.

The *battery-room* contains 266 chloride cells, cast with 31 plates in lead boxes; their capacity is 750 ampere-hours for five hours, or 400 ampere-hours for one hour. The cables are Glover's single-wire "Diatrine" lead-covered type; the feeders are laid on the solid system and the distributors are steel-armoured and laid direct in the earth. A new feeder has been laid of Henley's paper-insulated lead-covered type, 1 square inch in section.

The street lighting is carried out by 36 Crompton arc lamps run four in series on the 230-volt mains. For private lighting the equivalent of 7,700 8-c.p. lamps was connected last January. The price charged is 5d. per unit for the first hour's use per day of the maximum demand, and afterwards 2½d. G. H. B.

2504. *Sunderland Electric Tramways.* (Electrician, 45. pp. 658–662, Aug. 24, 1900.)—The track is laid with 96-lb. girder-rails of high carbon steel, tensile strength 46 tons per square inch. The steel fishplates weigh

64 lbs., and the sole-plates 34 lbs. The rails are bedded on to 6 to 1 concrete, pasted up with 3 to 1 cement mortar. The joints are bonded with double 000 Columbia bonds, cross bonds being placed opposite to each pole, and the track bonds between each pole. Span wires ($\frac{7}{14}$) with rosettes have been used in Fawcett Street, and centre bracket and side poles elsewhere. Where bracket poles are used, the trolley wire of No. 0 S.W.G. is flexibly suspended by the fiddle-bow suspension. The poles are in three sections, and made to stand 1,000, 1,500, and 2,000 lb. strains, according to their position on the track. The brackets are of Mannesman tubes, and the details of the bracket-work, instead of being of cast iron, are of gun-metal painted. The entire equipment of the track is by Dick Kerr & Co.

Callender's cables are drawn into Sykes earthenware conduits placed in the clear way between the tracks. In addition to the return cables, two points, one near each terminus, are connected to a negative booster at the station through 0·8 and 0·25-inch cables. The negative boosters are made self-regulating by carrying the outgoing current through the series-windings of the boosters, thus making the boosted negative volts proportional to the load on the traction generators.

The cars, of which 26 are already built, are double-decked, mounted on Brill trucks, and carry 56 passengers. A useful feature is the illuminated destination boxes carried at each end. The trolley standard is in the centre of the car deck; the greatest overhang of the swivel arm is about 7 feet, and the trolley wire is 22 feet clear of the ground.

Electric power is being provided from the Corporation Electric Supply Station, but the traction plant is distinct from the lighting plant. The chimney of the generating station is only 45 feet high, and on this account mechanical draught is required. It is found that by using fans, highly bituminous slack fuel can be burned without producing smoke. The traction generators are four in number, and consist of three-crank Belliss engines coupled to four pole dynamos giving 450 H.P. at 550 volts. E. K. S.

2505. *Metropolitan Railway, Paris.* **A. Dumas.** (Génie Civil, 37. pp. 97–219, July 21, 1900.)—This article, which is profusely illustrated on every page, and has five double-page plates of dimensioned details attached to it, comprises (i) an historical and general description of the proposed network of underground electric railways to be built by the city of Paris, and (ii) a detailed description of the portions already completed.

Six lines, with a total length of 65 kilometres, have been definitely arranged for. The city is to do all the substructure, estimated to cost 150 million francs, and a Concessionnaire is to build the superstructure (estimated at 50 million francs) and exploit the line for his own benefit for thirty-five years from completion, subject to a Government duty of 0·05 fr. on each second-class ticket and 0·10 fr. on each first-class ticket. Tickets are to be available from any one station on the Metropolitan to any other, and are to cost 0·15 fr. second class, and 0·25 fr. first class. Of the 65 kilometres definitely settled, 70 per cent. is underground, 16 per cent. is viaduct, and the rest cuttings. Steel Vignole rails will be used, 15 metres long and weighing 52 kg. per metre. A frequent service of short trains will be given, at a maximum speed of 36 kilometres per hour.

About 14 kilometres is actually completed, all of which is underground. Full dimensioned details of the tunnels are given. The rails are laid on creosoted sleepers to 1·44 metre gauge, with joints staggered and supported. Every 8 metres, longer sleepers are used to support the conducting rail on insulators. The return circuit is through the track rails, whose joints are bonded with fine copper conductors of 0·15 metre diameter. Twenty-five stations have been built. The tunnels are electrically lighted throughout. Auxiliary tunnels have been driven through to the Seine to facilitate removal and delivery of material. The total cost of the substructure on the part completed is approximately 37 million francs, equivalent to 2,646·22 fr. per metre run. Shields on the Chagnaud system were used. The rolling stock is of the corridor type, with two side doors to each car, one for ingress and the other for egress only. The motors are carried in a cab forming part of the front car. Current is collected by a shoe suspended flexibly from the oil boxes of the motor carriages, each of which carries two Westinghouse motors. The motors are rated at 100 H.P. each, at 450 r.p.m., and drive by single-reduction spur-gearing, the diameters of the wheel and pinion being respectively 630 mm. and 265 mm. The motors are series-wound, and can for short periods give double their rated power. Series-parallel controllers are used. A speed of 36 km. per hour is allowed, but the actual speed does not exceed 30 km. per hour. At present there is a 10-minutes' service, which is to be increased to a 2 to 5-minutes' service from 5 a.m. to 1 a.m. In addition to an air-brake, all the cars have hand-brakes and emergency electric brakes. The Hall block-system of signalling is used, whereby the train itself blocks the lines by depressing a pedal which closes an electric circuit operating the signal.

A power station to supply the whole of the lines is nearly completed. In the meantime current is bought from various existing companies. The power station will have three batteries of six boilers each, one 1,500-kw. direct-coupled continuous-current set for 600 volts, and four 1,500 kw. three-phase direct-coupled sets for 5,000 volts and 25 periods. There will be one rotary transformer substation, where there will be a Tudor battery, as well as one at the power house itself, the batteries being intended to act as "flywheels." The boilers will be of the semi-tubular type; the engines are vertical compound Corliss condensing, each giving 2,600 I.H.P. at 70 r.p.m., with cylinder diameters 1·1 and 1·8 metres respectively, length of stroke 1·5 metres, and a flywheel 7·5 metres in diameter weighing 63,000 kg. The multipolar dynamos, by Creusot, have steel magnets and slotted bar-wound armatures. The alternators have rotating fields and stationary armatures. They are excited at 200 volts by either of two 50-kw. motor-generators, running at 525 r.p.m.

The stationary transformers are of 250-kw. size, grouped in two banks. The rotaries run at 250 r.p.m., and have a capacity of 750 kw. They will be arranged to take six-phase currents obtained by suitable grouping of the stationary transformers. E. H. C.-H.

2506. *Geneva Electric Tramways.* (Street Rly. Journ. 16. pp. 575–581, Aug., 1900.)—These tramways serve the city of about 100,000 people, and the canton with a population of 120,000, the area being 109 square miles. When the scheme is completed the expenditure will be about five million dollars for 100 miles of track. The gauge favoured in Switzerland is only 1 metre, which is also the gauge for the greater part of these tramways.

The company has 36 cars and is adding 90 new ones for the electrical equipment of which Westinghouse motors and controllers will be used. The network of feeders is laid in terra-cotta conduits, the number of ducts varying from 20 to 4. The cables are jointed as follows: They are first scarfed at an angle of 45°, and the base ends separated about $\frac{1}{32}$ inch and clamped in a bullet mould, into which nearly pure tin-solder is run. This at once solders the ends of all the wires together and surrounds the whole core with an enlarged ferrule. The joint is then served, and a sleeve of lead pipe is slipped over, the ends of the sleeve being connected to the cable by means of a cast joint made of very fusible solder. An air pump is then applied to the pipe and the air exhausted until a vacuum is obtained, thus testing the integrity of the envelope with the soldered ends. If the joint is found to have good insulation, a hot, melted, resinous compound is run into a pipe leading into the joint, the opening into the joint having been previously stopped with a wax plug. The hot compound melts the plug and the vacuum forces in the compound, with the result that a joint is obtained of higher insulation than the normal cable itself.

The company is relieved of all necessity of generating its own current, as the city has developed the water power of the lake and river at its own expense. They have established a generating station at Chevres, about four miles down the Rhone. The original plant was by the Œrlikon Company, but Brown, Boveri & Company have recently supplied six 1,200-H.P. two-phase machines wound for 45 periods per second, and a potential of either 5,500 volts or 2,750 volts at will. They are of the umbrella vertical-shaft type with fixed armature and revolving field, having 46 poles carried by a cone-shaped magnet-wheel. The current delivered at Coulouvreniere for the street railway work is received at present by a 600-kw. machine, which delivers direct current to the system at 560 volts. The contract with the city is at the rate of 12 centimes per kw. hour for all current up to 1,800,000 kw. hours per annum, and above that at 9 centimes. The current is delivered through meter, and is available night and day. E. K. S.

2507. *Electric Traction on the Orleans Railway, Paris.* **J. A. Montpellier.** (Électricien, 19. pp. 344–346, June 2, 1900.)—The *Chemin de fer d'Orléans* has adopted electric traction for the underground extension of 4 km. which joins its Austerlitz station with a new station built on the site of the old Cour des Comptes. At the junction with the steam lines the various tracks are traversed by an electric transfer table 9 metres long, capable of carrying either the electric or the steam locomotives. There are eight electric steam locomotives, resembling the previous G.E. engines at Baltimore and Hoboken. They carry four motors on the four axles, with single-reduction gear, and are controlled by a series-parallel controller with magnetic blow-out. The locomotives normally take 500 kw. and weigh 40 tons, but can be weighted up to 46 tons to secure the extra adhesion necessary to draw a 250-ton train up a steep grade which occurs at one point on the line. Current is supplied through a third rail carried on paraffined blocks on the sleepers. The return current is through the track rails. The locomotives have three brakes in front and three behind. The central station, which supplies all the power and light, contains two 1,000-kw. three-phase generators, giving 5,500 volts at 25 periods per second, and has room for a third set. The engines are of the horizontal type. The primary current is used direct only in certain constant-speed auxiliary motors. The line is fed from two substations containing stationary transformers and rotary converters, each giving 250 kw. at 550 volts. These converters are connected in parallel with a battery arranged to supply the extra current required during the short period of acceleration. The lights are chiefly in series on a 500-volt continuous current circuit, fed by six 100-kw. rotary transformers, driven by three-phase synchronous motors run off the 5,500-volt circuit. The accumulators (Tudor) are in two batteries, each having a capacity of 1,100 ampere-hours on a one-hour discharge.

These batteries serve to equalise the load on the generating plant. The primary cables are armoured triple concentrics laid in the ground or in masonry ducts. E. H. C.-H.

2508. *Utilisation of Water-Power for the Electric Railway System of Minneapolis and St. Paul.* **E. P. Burch.** (Street Rly. Journ. 16. pp. 723–727; Discussion, p. 727, Sept., 1900. Paper read before the North-Western Railway Club, April 10.)—The source of power is the upper Mississippi River. A dam has been constructed below St. Anthony Rapids, giving an 18-feet fall. Turbines developing 10,000 H.P. drive directly two 1,000-H.P. low-pressure direct-current generators, which supply the nearer lines, and eight alternators generating at 3,500 volts, which supply substations at Minneapolis and St. Paul, the latter by a transmission line 9 miles long taking 2,000 H.P. at 12,000 volts. At the substations the alternating current is reduced in pressure and converted into direct current. The efficiency of the whole power system is very low. Of the 10,000 H.P. developed by the turbines the motors in ordinary work do not yield over 5,000 H.P. The cost of power is but 14 per cent. of the total cost of operation.

The paper is illustrated by a diagram showing the "flowage" of river, cross section of dam, map of dams, cross section through generating stations, drawing of turbines, and diagram showing method of splicing three-phase cables. J. T. R.

ELECTRIC TRACTION AND AUTOMOBILISM.

2509. *Calculation of Distributing Systems for Electric Tramways.* **H. M. Sayers.** (Inst. Elect. Engin., Journ. 29. pp. 692–729; Discussion, pp. 729–741, July, 1900.)—The conditions in lighting and traction systems are essentially different. In the former there is usually a short daily period of heavy load and a small load factor, and consequently economy in capital expenditure is of relatively great importance. In a traction system the special conditions are (1) high-load factor, a large output being generally required for fifteen to eighteen hours a day; (2) large permissible variation in pressure, 10 per cent. causing no inconvenience; (3) unsymmetrical arrangement of the two conductors. Practically all the drop occurs on the outgoing insulated side of the system. The author gives a method of working out the most economical current density, starting with Kelvin's law. He concludes that the limiting distance due to loss of pressure in feeders designed on economical principles is two to three miles from the generating station, and this limit is unaffected by traffic density, but varies directly as the cost of energy. For distribution over larger distances three systems are in use in the United Kingdom:—(i) The multiplication of continuous-current low-tension stations, (ii) the use of battery substations charged from a single generating station, (iii) the use of one high-pressure polyphase station distributing to substations whence low-tension continuous current is supplied. The second system is little used, and its application seems limited to cases of infrequent service on distant lines, such as arranged by J. Hopkinson at Leeds.

Assuming a permissible drop of 10 per cent., or 50 volts, on the trolley wire, and a uniform distribution of cars, the average drop over the whole system will be 5 per cent. in the trolley line, to which must be added the loss in track feeders, probably 2½ per cent. As the "interest" item of distributing costs equals in value the "loss of power" item, it follows that the distribution costs in such a continuous-current system will equal 15 per cent. of the value of the power delivered to the car, and 115 units must be generated for every 100 units required at the cars. In a multiphase transforming system the overall efficiency cannot be taken at more than about 80 per cent., which means 125 units generated for every 100 units used at the cars. The author concludes that for equal costs under these two systems the cost of generation at the single high-tension station must be less than 88¼ per cent. of the cost at the low-tension stations by the cost per unit of interest, attention, and stores due to the transformers.

The principal part of the paper is unsuitable for abstracting, being the working out in detail of the costs of distribution in a particular example, with single and multiple continuous-current stations, or with a multiphase station. Appendices give detailed calculations for "boosted" feeders and track feeders.

Discussion.—**E. Thomas** pointed out that the most economical distribution does not necessarily correspond to the most economical system considered as a whole, and **J. Swinburne** urged reconsideration of the three-wire system for tramways, and suggested the use of a booster on the middle return wire. E. H. C.-H.

2510. *Polyphase Electric Traction.* **C. A. Carus-Wilson.** (Inst. Mech. Engin., Proc. 3. pp. 435–458 ; Discussion, pp. 459–462, June, 1900.)—An important paper describing the equipment of the Burgdorf-Thun three-phase railway, and giving results of tests made by the author to find out the performance in acceleration, coasting, &c. Two of the three appendices also give interesting notes on the action of a polyphase motor, with special reference to its behaviour as a railway motor ; also particulars of the windings of the Burgdorf-Thun motors.

With steam traction it is necessary to make up trains of considerable length to meet expenses ; hence where the traffic is small the train interval is large. With electric traction single independent cars can be run economically at frequent intervals. This breaking up of the traffic into small units has also a marked influence on the punctuality of the train service, as it enables the staff of the various stations to handle the traffic and luggage with greater facility. It is especially an advantage when temporary increases of traffic have to be handled. The punctuality is also affected by the question of gradients, and whilst the continuous-current motor shows a large reduction in speed at heavy loads, the polyphase motor, on the other hand, runs at a practically uniform speed, entirely independent of load or grades. Experiments were made by the author in which the records showed no appreciable variation of speed when the load on a motor car on the Burgdorf-Thun line was increased from 32 to 68 tons, and only 2 per cent. fall when a 50-ton train ran from a level up a grade of 1 in 40. With the polyphase system a temporary increase in the traffic can be carried by adding trailers to the motor cars up to the full power of the motors with no complication of controllers or increase in the working staff, and without any appreciable influence on the speed. Particulars are given of the Burgdorf-Thun railway, for which see also Abstract No. 765, 1900.

The author goes into the question of acceleration very thoroughly, and makes an interesting comparison between this line and the South Side Elevated Railway (continuous current) at Chicago, which is very similar in weight, &c., and is equipped on the Sprague multiple unit system. It is shown that the continuous-current equipment can get up a speed of 24 miles per hour with 39·5 watt-hours per ton in 37 seconds, as compared with 45·1 watt-hours in 30 seconds with the three-phase equipment. Thus the continuous-current motors use 87 per cent. of the energy required by the three-phase motors, while the three-phase motors get up full speed in 81 per cent. of the time taken by the continuous-current motors. The reduction of energy in the continuous-current motor is due to the use of the series parallel controller, but the author further deduces from his experiments, and the particulars given in F. J. Sprague's paper, that the maximum power input as obtained in actual practice with the three-phase motor is only about 70 per cent. of that with the continuous-current motor.

The tests go to show that polyphase motors are admirably adapted to getting up speed, and that the acceleration can be maintained uniform up to full speed. The comparison of results with those obtained on one of the most complete continuous-current equipments shows that there is very little difference between the two in economy of starting. The continuous-current motors have a slight advantage in the amount of energy expended, while they occupy a longer time in reaching high speeds, and require larger maximum power inputs than the polyphase motors.

Discussion.—**S. F. Walker** was of opinion that the continuous-current motor would stand overloading right up to the point where either its insulation burnt up or some part of its arrangement for transmitting power mechanically to the driving axles broke down. The polyphase motor, on the other hand, under present structural conditions would not go beyond a certain overload. In his reply **C. A. Carus-Wilson** stated that the breakdown load of a polyphase motor was 1¼ times the rated maximum safe working load, a limit which would fairly cover any temporary overload in practice. Further, the polyphase system admitted of the whole installation, from generator to motor, being worked without any kind of safety or automatic cut-out, even safety fuses being dispensed with if suitable generators were used. Under these circumstances an interruption in the train service due to overload was far less likely to occur than with the continuous-current system, where safety fuses and automatic cut-outs were essential. E. K. S.

2511. *Electric Traction.* (Amer. Inst. Elect. Engin., Trans. 17. pp. 311–335, May, 1900.)—**F. Sprague,** in opening this discussion on Boynton's paper [see Abstract No. 1595 (1900)], remarked that when the electrical operation of a trunk-line system was under consideration, the freight service must not be forgotten. Freight service differs considerably from passenger service, and can be most economically transported in long trains drawn by a single locomotive with a small crew of men. For electric traction to be a success, there must be nowhere on the line a localisation of large units at long intervals; the more units and the closer together they are the better. They must be evenly distributed over the system. One of the great advantages of electricity as a motive power is that it can be adapted so as to use the whole weight of the train for traction by means of the "multiple unit system." This system also has the advantage that the power of a train is directly proportional to its capacity, no matter how long it may be. With electric locomotives the limitations of the system are very much the same as with steam.

The two most important things which have been brought forward and practically developed during the last two or three years are storage batteries (as a means of equalising the load) and the multiple unit system. The storage battery is a necessity in any large development of the application of electricity to traction.

The cost of power stations is more like $200 per kilowatt output than the $80–90 spoken of by Boynton.

Ice can generally be kept from the third rail by running a fast car over the lines on the approach of sleet, and in the multiple unit system the front shoes cleared away the ice whilst the back ones took the supply of current, and there was very little sparking.

Boynton, in replying, said that he was not quite able to associate the multiple unit system with all conditions of steam railroading, but that doubtless for suburban conditions of traffic in cities it was applicable. He was of the opinion that electric traction would begin under steam railroad conditions, perhaps afterwards developing into a multiple unit system. The use of storage batteries in connection with electric traction is undoubtedly on the increase. With reference to ice on the third rail, he had experienced a good deal of trouble with a certain kind of ice which stuck like a coat of varnish. It would not chip off, but had to be planed off by specially arranged steel tool planers. P. D.

2512. *American Tramway Practice.* **A. E. le Rossignol.** (Electrician, 45. pp. 711–712; Discussion, p. 712, Aug. 31, 1900. Paper read before the Municipal Electrical Association at Leeds, June 23.)—The present practice in tramway construction leans towards the erection of a large central power station with high-pressure distribution to substations. Coal-handling and storing machinery is always used, and thus the fuel costs are kept remarkably low. The companies are reticent as to actual figures. The generating sets are large, of the open slow-moving type, with mechanical oil supply. The question of providing adequate boiler power on a reasonable amount of floor space to correspond with the engine floor space has been met by the adoption of two or more boiler floors one above the other, surmounted by huge coal bunkers at the top—a method which exemplifies the trust placed by American engineers in steel-framed buildings.

Underground conduits seem to work very successfully, but have been introduced only in New York and Washington. Two conductors are always used, and means provided for changing these conductors on to either positive or negative bars, so as to enable traffic to be kept running even with one conductor grounded in any or every section.

In no case, so far as the author is aware, are return current boosters used, so that even with good bonding the maximum fall is great. There is no limit fixed by law; the only limit the companies recognise is an economic one. Electric and cast welding are employed, the latter being most favoured; no supplementary bonds are used, as would be required in this country to keep within the Board of Trade limit of 7 volts.

Discussion.—**C. H. Wordingham** was of opinion that all drawing-in systems will have to be given up, as they are fatal to the cable. **S. Z. de Ferranti** said that he noticed that all the important switches (in the Metropolitan Company's Station, New York) were placed two in series. He mentioned that S. H. Short was of opinion that having several stations was cheaper in first cost and running than one large power station as in New York. E. K. S.

2513. *Rail-Joint and Bond Resistances.* **W. E. Harrington.** (Frank. Inst., Journ. 149. pp. 401–419, June, 1900.)—A Weston millivoltmeter was connected by contacts of Edison-Brown alloy across 24 inches of various rails, with and without various joints and bonds. Tests were made by placing the rail in series with an ammeter and water rheostat, and taking readings of the drop in millivolts at each reading of current through the rail. The rail tested was a 9-inch girder rail ("P. S. Co.'s Section No. 200"), and the average resistances between the voltmeter contacts at 24 inches on the rails were found to be:—

Test.	Ohm.	Percentage Difference from Resistance of Solid Rail.
Solid rail	0·000020	...
Plain cast weld	0·000026	+ 30
Cast weld with copper contacts......	0·000040	+ 100
Plain cast weld with 2–4/0 Bryan bond	0·000018	— 10
Plain cast weld with ½ × ⅞ Edison-Brown alloy plug	0·000021	+ 5
Plain cast weld with 30 in. × 4 in. × ⅛ in. sheet copper outside	0·000016	— 20

From other tests with various rails and bonds it appears that the conductivity of a joint is quite comparable with that of the rail itself, and, if double bonding is used, the resistances can be made less than the rail resistance, particularly with bonds other than those expanded into holes in the foot or web of the rail. The author sums up as follows:—(*a*) The cast weld joint alone has a resistance 30 per cent. greater than that of the solid rail. (*b*) The use of sheet copper, as furnished by the Ajax Company, makes the combined resistance 20 per cent. less than that of the solid rail. (*c*) Where the cast weld joint is not employed, and the usual fishplate form of construction is adopted, the flat sheet surface-contact form of bond, known as the "Ajax," makes the most efficient type of bond, both electrically and mechanically, making the resistance only slightly more than that of the rail, whereas the other types make the resistance from three to four times more. E. H. C.-H.

2514. *Fall of Potential along Tramway Rails.* **E. Parry.** (Electrician, 45. pp. 595–598, Aug. 10, 1900.)—The author first considers the problem of the distribution of potential along a bare conductor laid in the earth, the ends of which are maintained at potentials + V and — V respectively. The value of the potential v at intermediate points is found by solving the equation—

$$\frac{d^2v}{dx^2} = \frac{Lh}{Ak}v \qquad (1)$$

where v is subject to the condition that—

$v = +V$ when $x = 0$,
and— $v = -V$ when $x = X$.
Also— $A =$ the cross-sectional area of the rail,
$L =$ the surface area of the rail per unit length, in contact with the earth,
$k =$ the conductivity of the material of the rail,
$h =$ the external conductivity between the rail and earth.

The equation is the same as that given by Fourier to find the temperature at any point of a heat conductor exposed to the air whose ends are maintained at constant temperatures. From (1) v is found, and hence the current $\left(-kA\frac{dv}{dx}\right)$ is also determined. The author found that for a modern type of girder rail, $\frac{L}{A}$ was equal to 3·15. Following H. F. Parshall, he takes k to be $\frac{10^6}{7{\cdot}35}$, and by experiments over lengths of seven miles and four miles of double track, he found h to be $\frac{1}{737{,}000}$. From these data he finds that—

$$\sqrt{\frac{Lh}{Ak}}=\frac{1}{180{,}000}$$

Curves are drawn illustrating the solution of (1), and showing also the ratio of the maximum and minimum currents in the conductor for various lengths of track. The maximum current density in the rails is assumed to be 2·5 in all cases. He shows, for example, that when the track is eight miles long the stray current is 54 per cent., and the total potential difference is 7·8 volts. A practical numerical example is also given, showing how to take into account the resistance of the joints along the rails. A. R.

2515. *Joint Construction.* **H. Koestler.** (Street Rly. Journ. 16. pp. 399–400, May, 1900. From a paper read before the Fachgruppe der Bau- und Eisenbahn-Ingenieure, of Vienna, Jan. 18.)—On the Electric Underground Railway at Vienna the "Stossfangschiene," or "Barschall Joint," has been in use for from 1¾ to 2¾ years. This joint has in place of the outside angle plate, a rolled piece of rail 550 mm. in length, made of the same material as the rail itself, and shaped in such a way that for a distance of 180 mm. its running surface is on the same level as the running surface of the rail. The ends are chamfered off so that in the course of time surfaces are produced which will effect a smooth transition of the wheel from section to section. Between the outside and surface rails is an intermediate eight-shaped piece. The running is smooth and noiseless, the wear on the joints has not been noticeable, and only 1 per cent. of the joints have been replaced on account of failure of material, which occurred a few days after the road was opened. The wear at the joints has been no greater than at any other portion of the rail, and there has been no flattening at the joint proper, which might have been produced by a slight drop of the wheels at that point. Upon careful examination of the intermediate rail between the two others, it was found that it did not press into the head or base at any point, that it was tight along its whole length, and that there had been no friction, as is the case with most fishplates. There have been no breaks recorded of the inner rail on a total of 12,000 joints, and no perceptible wear of this piece. In fact, it has been found that the rail wears and works as a unit. It has further been found that it is not necessary to tighten the joints as frequently as is the case with ordinary fishplate joints, and this reduces the cost of maintenance considerably. In Vienna it is concluded that the extra first cost of this joint will be made up by the increased life of the rail. E. H. C.-H.

2516. *Electrolysis by Earth Returns.* **A. B. Herrick.** (Street Rly. Journ. 16. pp. 396–399, May, 1900. Paper read before the New York Electrical Society, April 20, 1900.)—In a 9-inch girder rail the surface of contact is about 1,300 square feet per thousand feet of rail. Modern paving methods, with cement underneath the rail, increase the resistance to current flowing away from the rail, and asphalte or waterproof pavements over the roadway protect the underlying soil from surface water, and in this way increase the natural resistance of the earth's circuit. When the current leaves a metallic surface which is buried in the earth, it does not carry with it the decomposed metals, as in a plating bath, and deposit them on the kathode. On the contrary, the products lie adjacent to the surface acted upon, and when the metal is iron they generally form oxides. These oxides increase the resistance to the flow of current and, consequently, the resistance also of the return circuits by way of the earth. This effect is actual as well as theoretical, and the gradual falling off of the current returned by the water-pipe system can be noticed in roads where the ground returns are properly located and bonding is maintained. With a lead service pipe connected to an iron pipe there are two metals which, when buried in the earth, form an earth battery which will cause a current to flow between them when their ends are connected together, as is the case when a cast-iron pipe has a lead service pipe tapped into it. This matter was seriously considered when iron pipes were first used for underground systems, and the method of connecting finally adopted was to use a brass nipple between the iron and lead pipe ; a brass and iron connection corrodes and forms a high-resistance contact, thus breaking up these local earth currents. When the railway current seeks a return to the rails these lead service pipes offer the nearest path through the earth to the rails, as they usually pass under the rails to cross the street to a water connection on the opposite side. On carefully digging away the earth between the lead service pipes and the rail where it has passed a current to the rails, it is found that threads of lead oxide reach from the lead pipe to the rails through the earth ; in some cases the lead oxide shows great migratory powers. Actually when the real destruction is measured with cast-iron plates buried in the earth and kept moist, the amount of metal destroyed is only 3·46 per cent. for the first 100 hours, of the theoretical rate for iron in its proper salt solution ; this rate falls rapidly after 100 hours. The resistance of clay with 6 per cent. moisture, is on the average about 2·7 billion times, and of sand with 8½ per cent. moisture, about 1·3 billion times that of copper ; in tidal districts where the earth is saturated with salt water, the earth resistance is as low as 1 billion times that of copper.

The methods of testing employed to discover the flow and points of departure of subterranean currents are as follow. First, to find where the currents enter the water-pipe system. The water-pipe system is cleared of all known connections to the rails or negative bus-bar, and between the negative and the water main near the station, a recording ammeter is inserted, and a second recording ammeter in the ground return circuit. A car is provided for use as a test-car with a water-barrel rheostat, made of two plates of ⅛-inch iron about 14 in. by 24 in., and filled with water, using bicarbonate of soda to reduce the resistance of the water ; when the water is heated by the current to about 60° F. it will carry about 140 to 200 amperes. This rheostat is connected between the trolley and ground with a switch in circuit. The car is run after traffic has been stopped ; the assistant is provided with a map of the route on which are marked quarter-mile intervals. At the end of each interval the car is stopped and the circuit closed. By arranging beforehand the number of times he must pull the switch, or the length of time he must leave the switch open at each stop, a system of breaks will be made by the recording ammeter, which will give on the chart the position of the test car on the system. The next step is to find the current that has passed into the water-pipe system through the earth resistance between the rails and the piping system. Two adjacent water-plugs are connected together, first by a voltmeter line, and the voltage V_1 is read. Then these two plugs are connected together through a low reading ammeter, and readings are taken of the amperes A, flowing at the voltage V_2. The true current X, flowing in the pipe is given by the proportion, $V_1 - V_2 : V_1 :: A : X$. The remedy for electrolytic troubles is to form a system of electrical drainage of the water-pipes, taking care, however, not to thereby increase the flow of current into the pipes. To secure this, a return feeder of suitable resistance must be connected to the pipes at a point where there is no difference of potential between the rails and the pipes. The water company can almost entirely prevent all trouble by using coated iron instead of lead service pipes, and by using high-resistance sulphur and iron filings for joints instead of lead. E. H. C.-H.

2517. *Electrolysis by Earth Returns in Brooklyn.* **S. Sheldon.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 337–342, May, 1900.)—During busy hours there are 1,100 cars on the tracks in the borough of Brooklyn, supplied with a total of 47,000 amperes from seven power stations. There are five paths for the return current: (i) The rails; (ii) the East River (this path takes a large proportion of the return current at certain hours when most of the cars are bunched at the "down-town" end); (iii) return feeders; (iv) the Elevated Railway structure; (v) water- and gas-pipes; telephone cables and Edison "tubes." The difference of potential between the rails and the gas- or water-pipes sometimes reaches 25 volts. Between the two ends of Brooklyn Bridge there has been 20 volts, and 40 volts is not unknown between a power-house and the most distant point supplied by it. The water mains are cast, either of hard and tough "Scotch" iron or softer American iron. In no case has electrolytic corrosion of water mains been discovered, but many wrought-iron service pipes with malleable-iron or brass fittings have been destroyed. The Gas Company claim that since the advent of electric traction, the leakage has increased abnormally. It now amounts to 13 per cent. of their output. The lead covering of the telephone cables has been much pitted. The true cause of the immunity of cast-iron is that, in the casting of pipes in sand moulds, the hot iron unites with a layer of the sand to form a silicious compound, probably silicate of iron, which forms a thin coating over the surface of the completed pipe. This coating is extremely thin, and is a non-conductor of electricity. It is not continuous, but contains perforations in many places. If, however, a current be made to pass for a few moments under a moderately high impressed E.M.F. the rough sand-pocked surface becomes conducting throughout. The protecting film or skin seems to act like the non-conducting film thrown down in an aluminium cell. The resistance of the soil is important in preventing corrosion, and may be determined from the formula $X = R\,[(E \pm E')/\theta - 1]$, where R is the resistance of a low-reading voltmeter, and E', E, and θ are respectively its readings (i) across the two points between which the soil resistance is required (*e.g.*, between a hydrant and the rails); (ii) across the terminals of the battery only; and (iii) with the battery and voltmeter connected in series across the points. From many experiments, it appears that the soil resistances between rails and water hydrants lie between 10 and 35 ohms. The character of the pavements appears to have no influence on the resistance of the soil underneath [this is contrary to the preceding Abstract.] E. H. C.-H.

2518. *Electrolysis by Earth Returns.* **D. H. Maury.** (Eng. News, 44. pp. 38–42, July 19, 1900. Slightly condensed from a paper read before the American Waterworks Association, May, 1900.)—Since 1898 116 electrolytic breaks of lead service pipes have been recorded by the Peoria Waterworks Company. Investigations proved electrolysis by finding the lead redeposited in a thin

coating on the surrounding soil in the direction of the electric railway tracks. Similar deposition of metal was found in the cases of wrought-iron gas services and cast-iron gas and water mains, the soil around the joints of the latter being often stained with oxide of iron, while immediately in front of the ring of lead in the joint was a thick metallic deposit of lead. In 1894 one of this company's steel standpipes burst, more than a mile from the power house, and killed two persons. The whole inner surface of the vertical shell was covered with thin blisters, resembling those found on old cast-iron mains. These blisters were composed of oxide of iron, and underneath them was the original coating of black paint almost unbroken, but on scraping off the paint, pits would be disclosed of considerably smaller area than the blisters, and having a perfectly clean, bright metal surface. Cast-iron water-pipes are coated inside and out with a preservative coal-tar preparation, and in a spigot joint the spigot end only touches the bell end at the extreme end of the spigot pipe, as the latter is kept central in the bell by a ring of yarn before the lead is poured in and caulked. The author finds by tests that, contrary to the usual belief, the tar coating is not burnt or injured in any way by the heat of the molten lead. He tested the resistance of many joints, and found it to vary up to several thousand times that of the same length of continuous pipe; the resistance of the joint was unaffected by caulking the lead tightly or very loosely. The average resistance of a joint was 227 times the resistance of 4 inches of plain pipe. The resistances were found (in eleven months) to increase with age. Even if each joint only shunts 1 ampere of the current in the pipes the total effect of this 1 ampere is cumulative and serious, whereas 1 ampere leaving the pipes for the rails only makes one pit. Reducing the actual and relative conductivity of the pipe lines compared with the rail returns only results in more widely scattered but less rapid destruction. The only satisfactory preventive of electrolysis of underground metallic structures is to keep the return currents out of the ground. In Cincinnati 220 miles of track are equipped with the double trolley system, and after ten years' experience the managers declare that the cost of operation and maintenance is less than it would be with single trolley. An incidental advantage of double trolley is that both rails may be sanded. By recent Acts of Congress all new tramways or extensions in the District of Columbia are required to be on the overhead double trolley system.
E. H. C.-H.

2519. *Rolling Stock of the City and Waterloo Railway.* **D. T. Heap.** (Tram. Rly. World, 9. pp. 298–299, July, 1900.)—Some single-car stock has recently been placed on the Waterloo and City Railway, in order to give a more frequent service during light hours, while also reducing wear and tear, with the following favourable results:—(*a*) The consumption of energy per hour for the single-car service (exclusive of the power supplied for the auxiliary circuits) is less than when the 10-minutes' service was being maintained, although the average speed for the single journey has been increased to 18 miles per hour and a 5-minutes' service given instead of 10 minutes. (*b*) The acceleration of the car is very good, being at the rate of 1·74 feet per second on the "Up" road on leaving Waterloo. (*c*) The rolling load per hour over the running road is considerably reduced. (*d*) The maintenance expenses of the single cars will be less than is the case with the 4-car trains, the equipments being of the 2-motor geared type instead of the 4-motor direct type; and (*e*) these advantages have been obtained, as well as an increased passenger train mileage, with a reduction in the operating expenses. E. H. C.-H

2520. *Profits on Tramway Undertakings.* **C. H. Gadsby.** (Elect. Rev. 47. pp. 75–77, July 13, 1900. Paper read before the Tramways and Light Railways Association, Islington, June 29, 1900.)—Tables are given showing in detail the operating expenses on English horse, steam, and electric tramways, also on American electric trams. The average operating expenses per car mile for these different systems are respectively 9·5d., 10·7d., 6·9d., and 7·2d. American and English electric expenses agree closely in the details. In America it is common practice to get 100 to 120 miles per day out of a car; in England, 35 to 40 miles only is not uncommon. The author concludes that (i) it is generally possible by increased services to increase the gross receipts; (ii) the operating expenses do not increase at the same rate as the mileage, and generally at a less rate than the receipts; (iii) judicious increase in services generally results in larger net profits; (iv) electric traction is the readiest means of increasing the receipts, while at the same time reducing working expenses.

The following table shows the number and sizes of generators recommended for running various numbers of cars:—

No. of cars	5	10	15	20	30	40	60	80	100
No. of sets of generating plant, including reserve	2	2	2	2	2	3	3	3	3
Power of each set in kw.	16	125	175	225	300	200	250	300	350

E. H. C.-H.

2521. *Merriman's Rising Contact Stud.* (Elect. Engin. 25. p. 917, June 29, 1900.)—A new form of this is illustrated, and is claimed to overcome the drawbacks of the original form [see Abstract No. 772 (1900)] in which (i) grit was liable to get under the treadle and prevent its operation, and (ii) an ordinary waggon-wheel might accidentally operate the treadle. In the new form the treadle has to be wedged out of the rail groove by the car-wheel, this movement of the treadle raising the contact stud above the ground-level, while at the same time bringing it into contact with the feeder. Attached to the end of the lever arm that raises the stud is a heavy weight, which ensures the stud being pulled down again after the passage of the car. E. H. C.-H.

2522. *Electric Automobiles in Boston.* (Elect. World and Engineer, 35. pp. 895–897, June 16, 1900.)—A company formed in May, 1899, now handles 150 electric vehicles. The cabs are stored and cleaned on a first floor approached by an 8 per cent. grade, and the batteries charged on the ground floor. A lift is provided for exhausted vehicles, which are unable to climb to the first floor. There will finally be eight loading stands, with mechanism for pulling the batteries out and putting in fresh ones. The empty batteries are put into elevators and taken to the charging floor. Power is taken from the three-wire system of the Supply Company and the charging current is regulated by a rheostat for each battery, no "multiple bus-bar" arrangement being used. Current is kept approximately constant during charge. For moving about the building a special wire is provided running over a pulley at the centre of the roof, and counterweighted. A special portable pump is used for drawing up acid from the cells into a hydrometer. A ring of substations for charging is being formed on a four-mile radius from the central station. E. H. C.-H.

ELECTRIC LAMPS AND LIGHTING.

2523. *Electric Train-lighting.* **G. D. Shepardson.** (Elect. World and Engineer, 36. pp. 5–8, July 7, 1900.)—The Chicago, Burlington, and Quincy

Railroad has provided electric lighting in its "Burlington Express," designed to "eclipse every competitor." There are 265 lights on the train, and storage batteries are employed, charged at the ends of the line. Each car carries 48 cells of the Pullman and American types, rated at 160 ampere hours, and each weighing 56 lbs. The plates (4 positives and 5 negatives) very nearly fill their hard-rubber boxes, and this is found to prevent the acid "slopping" over when the train starts or stops rapidly. With the heavy vestibule cars now common the weight of the batteries averages less than 2 per cent. of the car it serves. After three years' experience of the system the master mechanic in charge is convinced that electricity is much the best system, and that a battery is more economical than an engine and dynamo. E. H. C.-H.

2524. *Series Enclosed Alternating Arc Lighting for Streets.* **W. L. Robb.** (Elect. Rev. N.Y., 36. pp. 532–533, May 23, and p. 563, May 30, 1900. Extracts from a paper read at the Chicago Convention of the National Electric Light Association, May, 1900.)—The author deals in a general manner with the systems which are at present used in connection with street-lighting from an alternate-current works supply, discussing the relative advantages of each.

The street-lighting of Hartford, Ct., is described. In all there are 804 street lights: 700 are operated from constant-current transformers in series on alternate-current mains, the rest from a constant pressure three-wire system. Eight 100-light, constant-current transformers are used, which run without attendance. They are constructed with a straight central core carrying at the ends two fixed primary coils, and between these, over the central part of the core, two movable secondaries. The motion of the coils is vertical, and they are slung by chains, to which is attached, outside the oil-filled cast-iron transformer case, a lever supported on a knife-edge and carrying a counter-balancing weight.

The lamps are trimmed once in six days, at an annual cost per lamp of $2; when open-type lamps were used, the trimming cost $8. The cost of carbons per lamp per annum is $1·50, that with open-type having been $5·84. The cost of inspection is unchanged. The cost of replacing inner globes is 30 cents per lamp per annum, but the breakage of outer globes is considerably less than was the case when open-type lamps were used. The total yearly saving by the substitution of enclosed-arc for open-arc lamps in carbons, trimmings, and repairs amounts to over $10 per lamp. In addition, the number of hours lamps have been out has been reduced about 50 per cent. A good deal of the success of enclosed lamps depends upon the cleaning of the cylinders, which ought to be done with brush and hot water every time the lamps are trimmed. By running the series transformers at about 90 per cent. of the full load the efficiency and power-factor of the system are satisfactory. The power-factor would have been considerably increased if shunt-wound lamps had been used, but differential lamps were adopted owing to their more satisfactory working.

The author afterwards compares the system of Hartford with other methods of arc-lighting from alternate-current supply, and from the results gives the opinion that, in the near future, generally speaking, when the alternate-current supply has a frequency of 60 per second, the series arc-lighting will be by series alternate-current enclosed-arc lamps; that when the frequency of the supply current is 25 per second, the series arc-lighting will be by series direct-current enclosed-arc lamps supplied with current from rectifiers. E. D. P.

TELEGRAPHY AND TELEPHONY.

2525. *Interior Telephone Systems.* **W. S. Henry.** (Amer. Electn. 12. pp. 401–404, Aug., and p. 443, Sept., 1900.)—The author describes "intercommunicating" systems having three or more telephones connected to the same system of wiring in such a manner that one station can call up any other without a central switchboard. An ordinary method, but not a good one, is to have a common return wire for all and a separate wire for each, the latter being connected in each office to a switch. The handle of the latter is movable over contacts numbered according to the numbers of all the stations. Then in each station No. 1 contact is joined to No. 1 line, No. 2 contact to No. 2 line, and so on. The switch handle of the station calling is moved to the number required, and when a ring is given the other stations are undisturbed. When all the stations are quiet the handles of the switches must rest upon the contact bearing the numbers respectively of the stations themselves, otherwise the system will be crippled. To avoid liability to this accident a recent device prevents the hanging of the receiver upon its hook when the intercommunicating switch lever is not in its normal position. The switch has an attachment that blocks the entrance to the receiver hook whenever the switch lever is off the "home" position, so that the latter must be returned to its appropriate stud before the receiver can be hung up. This device can be applied to almost any telephone. Another method, devised to obviate the inconvenience caused by failure to return the intercommunicating switch to its proper rest contact, consists in connecting the terminal of the telephone other than that joined to the common return to the arm of the switch as well as to its own line wire, so that if any station should accidentally leave the switch to a working contact other than his own, he does not interrupt communication between the others, and, being in derivation, will receive any ring that passes, and can be dismissed if he answers and is not required.

To adapt such a method for use with a common calling battery and vibrating bells in place of magneto-generators and polarised bells one more wire is required, joined to one pole of the battery (which can be placed in any situation) and to the "make" contact of the bell push in each station, the other pole of the battery being joined to the common return wire of all stations. The bell of the calling station does not ring, but only that of the station called. It is necessary to arrange the key to cut out the home bell owing to the difficulty in getting two vibrating bells to work well in series on one circuit. Selection switches are used as in the previous systems described, and should they be carelessly left off the "home" buttons the bells are left in parallel, and a calling current is subdivided and becomes possibly unable to ring the station required. E. O. W.